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ROENTGEN THERAPY OF CERTAIN INFECTIONS*

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THOUGH the major portion of the early work on the roentgen therapy of certain infections was done in this country, this procedure has gained more headway abroad during the past ten years. The subject, in this country, is not receiving from many radiologists the attention it deserves.

The multitude of conditions, infectious and otherwise, in which roentgen therapy has been advocated by some and exploited by others has probably caused definite and, in many instances, justified skepticism among the general medical profession.

Since the publication in 1916 of Dunham's article on the treatment of carbuncles, I have been especially interested in the roentgen therapy of certain infections, and in 1924 in the May issue of this JOURNAL and in 1925 in the October issue of the *Journal of the American Medical Association*, and in the *Southern Medical Journal* in 1926, 1927, 1930 and 1935, I reported our results in the treatment of carbuncles, cellulitis, erysipelas, parotitis, Mikulicz's disease, and so forth.

Leukocytic infiltration is an important feature of inflammations and it is well known that polymorphonuclears and especially lymphocytes are very radiosensitive.

The action of small therapeutic doses of radiation on various tissues has been studied by a great many pathologists especially by Maximow, Mittermaier, Heineke and Warthin. Leukocytes, particularly lymphocytes, are destroyed by very small doses. Warthin found a rapid destruction of lymphocytes almost in an explosive manner within fifteen minutes after the treatment. There are some changes in certain of the other cellular elements, but, where small doses are used, there is not enough definite change for this to be accurately demonstrated.

At first thought, it would not seem logical to destroy leukocytes which are acting as a protective mechanism against the infective process. On the other hand, the early destruction of some of these cells must more rapidly provide adequate amounts of the vital substances, ferment, antibody or what not, which are contained within the leukocyte for defensive purposes. As a rule, the more marked the leukocytic infiltration in the tissues, the quicker and more marked the response to irradiation will be.

Desjardins believes that the poor result obtained in some instances is due to the small amount of leukocytic infiltration in some infections.

Lacassagne and Vinzent, Motojima, and Schaefer have shown experimentally that small doses of roentgen rays favorably in-

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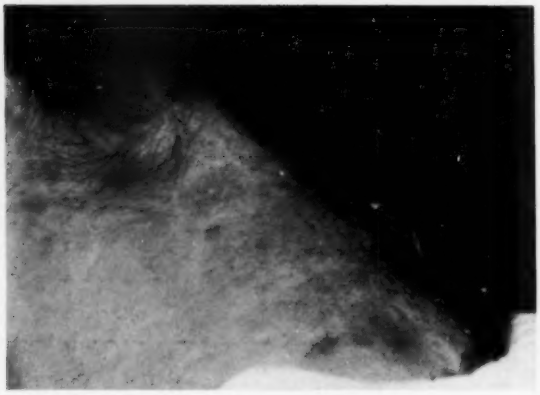

Fig. 1. Case 1. A large carbuncle of three weeks' duration. Poultices were being used but there was very little drainage. There was severe pain and the surrounding tissues were markedly indurated.

Fig. 2. Case 1. Two days following irradiation. There has been copious discharge with relief from pain and from marked swelling in the surrounding tissues.

fluence focal infections. The lesions healed rapidly while the control animals showed a high mortality.

Clinically the effect of irradiation is somewhat different in different types of infections and also varies as to the stage of development of the infective process.

Erysipelas. Streptococci localize in the spaces between the connective tissue and in the lymph vessels, chiefly in the most superficial layers of the corium. They produce, without suppuration, a cellular exudative inflammation of the skin and subcutaneous tissues. The disease usually lasts from about eight to fourteen days.

In 1924 we reported the successful roentgen treatment of 3 cases of erysipelas and we have treated a large number since that time. Irradiation is practically a specific for erysipelas as long as the lesion is local. Small early lesions nearly always disappear within twenty-four hours after the treatment. Large infected areas usually show an early limiting of the infection with a gradual disappearance of the condition within a few days. In some cases there has been marked walling off or pointing of the infection with the formation of a small, more or less central mass, 1 to 2 or 3 centimeters in diameter. To save time, the largest of these have been lanced. After a day or two of more or less watery discharge, they usually

Fig. 3. Case 11. This was at first thought to be an infected basal cell lesion. A number of similar cases since have all proved to be infected rhinophyma. The lesion was of three years' duration.

Fig. 4. Case 11. Six weeks after irradiation.

Fig. 5. Case III. Infected, degenerating angioma.

Fig. 6. Case III. After irradiation.

heal rapidly. The smaller ones gradually disappear without any further treatment.

The best results are obtained with small doses of unfiltered rays, using 85 kv., 125 r. This dose can, of course, be repeated if necessary. Where large uneven areas of the body surface are involved, one must be careful to see that the entire area, with surrounding peripheral edges, is treated.

Furunculosis. The entrance of staphylococci into either hair follicles or sweat glands causes a circumscribed phlegmon of greater or lesser extent with resultant necrosis of tissues and discharge of the infected material onto the skin.

In chronic furunculosis some of the lesions extend rather deeply into the subcutaneous tissues and filtered roentgen rays of good penetration are necessary at times for a good result.

Filtered roentgen rays give better results

Fig. 7. Case IV. Ordinary infected granuloma of eight weeks' duration following an injury.

Fig. 8. Case IV. Two weeks after irradiation.

Fig. 9. Case v. Ordinary granuloma with infection of finger and hand following a wound. Duration six weeks.

than the small doses of unfiltered low voltage roentgen rays in common usage. About 125 r, 125 kv., 4–6 mm. aluminum filter, 10 inch distance, at weekly intervals for several treatments not only causes the disappearance of existing furuncles but, of greater importance, almost always aborts newly forming ones which cannot be seen or felt.

In a large series our results have been almost uniformly good. Many of them after years of suffering have been cured by a few roentgen treatments. The following case serves as an illustration:

A white man, aged twenty-seven, nondiabetic. For five years he had suffered almost constantly with boils on the back of the neck. He had just spent six weeks in a hospital where boil after boil was lanced. Six weeks after the first roentgen treatment, his neck was healed and since then, after more than five years, he has not had another boil.

Irradiation is, I believe, without doubt the treatment of choice for furunculosis.

Carbuncle. Carbuncle is very similar to furuncle, except for its greater size and intensity. There is a strong tendency for the infection to spread into the contiguous peripheral and underlying structures. Though the large majority are due to the staphylococcus and are anatomically very similar to a complex boil, the clinical course of carbuncles varies greatly. In the usual ones a number of necrotic areas with separate openings form; but in a good many there is a very large, deeply infiltrating, hard, red, and extremely painful mass, with no tendency to break down for days and, at times, weeks.

After trying many different techniques, I believe that in the majority of instances, small doses of about 100 r, using 85 kv., unfiltered rays, give the best results. In some, two or three treatments are given. In very early carbuncle, a large dose of filtered roentgen rays will usually completely abort the condition. They are, however, very rarely seen at this stage and, not infrequently, it is difficult to determine whether the lesion is an early carbuncle or a cellulitis of different type. Naturally, when breaking down occurs, the wound must be kept clean and dead tissue removed; radical incisions are never necessary. Irradiation certainly in the large majority limits the spread of the infection, lessens the pain, increases the drainage,

Fig. 10. Case v. Two weeks following irradiation.

shortens the course of the disease somewhat, and I believe very definitely lowers the mortality. All carbuncles do not respond to irradiation as spectacularly as does furunculosis; but irradiation alone in most instances and in combination with heat, especially poultices, in others probably offers more than any other treatment. It is of course taken for granted that any severe systemic condition, especially diabetes, will also be treated.

In the literature practically invariably it is strongly stressed that most of the benefits of irradiation are seen in the early cases. This is as a rule true; however, some of our most spectacular results have been in late, extensive and very serious carbuncles. In 1920, at a hospital staff meeting, one of the surgeons reported what he considered to be a hopeless, very large carbuncle on the back of a white man, aged forty-eight, who was not a diabetic or syphilitic. He had made a wide criss-cross incision, six weeks previously; the entire area sloughed out and at the time he reported the case there was an enormous crater almost from scapula to scapula and only a watery discharge was exuding from the very thick edges of the carbuncle crater. The man had lost a great deal of weight, was weak and listless and appeared doomed. He was given about 150 r, 85 kv.,

Fig. 11. Case vi. Telangiectatic type of a granuloma with infection following a rope burn of the hand three months previously. Recurred twice following removal.

Fig. 12. Case vi. Four weeks after irradiation.

unfiltered roentgen rays that evening. During the night, there was a very copious, seropurulent discharge, and within twenty-four hours there was some improvement in his general condition. The carbuncle was showing new granulation tissues and a healthier appearance. He went on to an uneventful recovery. This has not been an unusual but a fairly common experience.

Infected Rhinophyma. Infection is rather common in rhinophyma or acne hyperplastica where there is marked enlargement of the sebaceous glands, connective tissue hyperplasia and tortuous and dilated blood vessels throughout the involved area. In several of these 300 r, 125 kv., 4–6 mm. Al filter has invariably cleared up the condition.

Infected Angioma. In infected angiomas a rather large dose is necessary, but here again the tissues treated are radiosensitive and excellent results can be obtained.

Granuloma. In ordinary granuloma, which is a tumor-like overgrowth composed of very cellular and richly vascular granulation tissue with an associated infection, 700 to 900 r, unfiltered roentgen rays at 85 kv. has given excellent results.

In telangiectatic granuloma, which usually occurs on the palmar surface of the hands and fingers, on the plantar surface of the feet and on the lips or around the mouth, there is practically always an associated infection, especially on the extremities. These lesions are not uncommon,

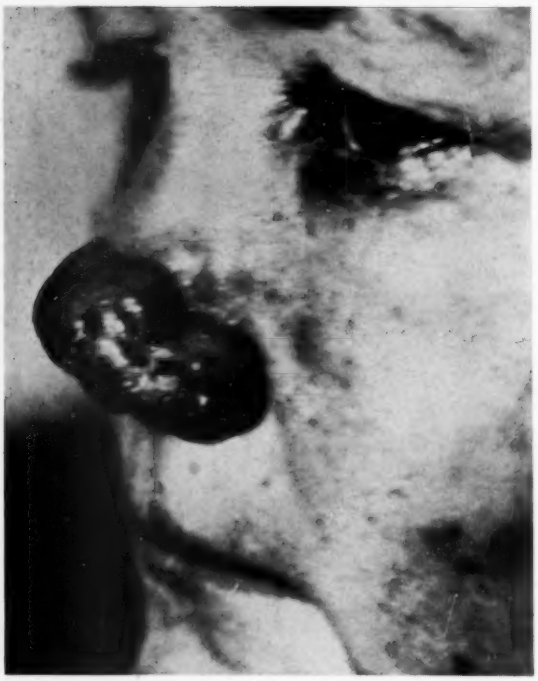

Fig. 13. Case vii. Blastomycosis involving the nose with nodules under the skin down almost as far as the angle of the jaw.

are bluish-red in color and except around the mouth usually have a pedicle. In addition to the cellular hyperplasia, there is an enormous overgrowth of the capillaries. Results following other treatment are very poor, due to a rapid recurrence of the lesion and spread of the infection. One, two or three erythema doses of low voltage, unfiltered roentgen rays, dependent upon the size and location of these lesions have invariably produced good results. Surgeons are only too glad to refer these cases to the radiologist, yet the radiologist has said so little about this work that the majority of our best surgeons are unaware of the value of irradiation in this field.

Blastomycosis. In some of the serious fungus infections, especially blastomycosis and sporotrichosis, where the lesions are limited, 500 to 600 r, 125 kv. 4–6 mm. Al filter, 10 inch distance, has given some excellent results. In some of these iodine was not used. However, in both blastomycosis and sporotrichosis, iodine therapy should be given along with roentgen therapy.

Parotitis. In 1924 I reported the successful roentgen treatment of 5 cases of subacute and chronic parotitis. A fairly large number of acute, subacute and chronic cases have been treated since that time with almost uniformly good results, following from three to five treatments, using 125 kv., 4–6 mm. Al filter, 10 inch distance, 125 r.

Rankin and Palmer reported 20 cases of postoperative parotitis following operations on the colon where suppuration occurred in only 2 of the 20. Here radium decreased the percentage of suppuration markedly. The mortality, which is usually from 35 to 60 per cent was very definitely reduced. Four of the 20 died, but 2 of these occurred two weeks, and 1, one month after parotitis had subsided and were considered as due to other complications. In only 1 instance did they feel that death was due to parotitis. Of course the mortality here is markedly influenced by the age and general condition of the patient, the severity of the

Fig. 14. Case vii. Six weeks following irradiation.

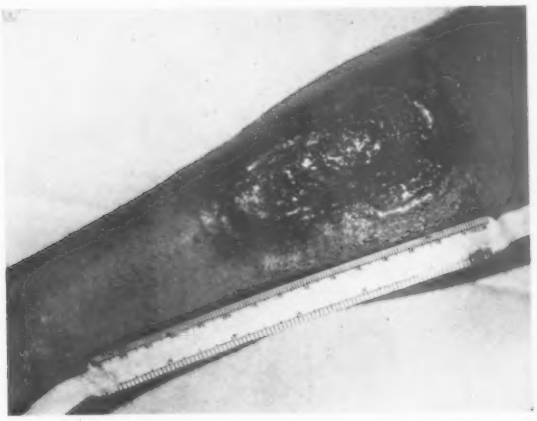

Fig. 15. Case VIII. Sporotrichosis of five weeks' duration.

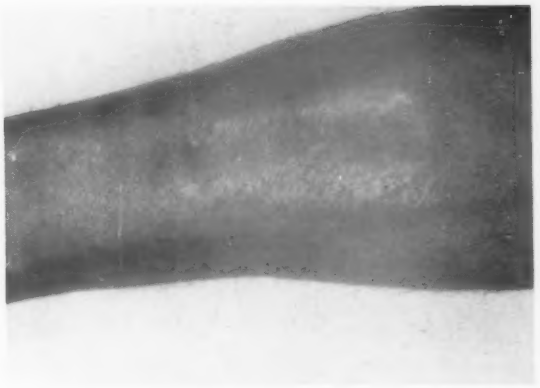

Fig. 16. Case VIII. Three weeks later, following irradiation.

primary pathology, other complications, etc.

Bowing, Dorrance and many others have reported good results following the use of radium or the roentgen ray.

Subchronic parotitis is not so rare, is usually unilateral and recurring but may be permanent, disfiguring and more or less painful. Roentgen therapy seems to be in this condition about as specific as any therapy in medicine today and other forms of treatment have not been at all satisfactory.

Mikulicz's Disease. Five cases of true Mikulicz's disease, which is supposed to be due to a chronic infection, have responded to from 100 to 400 r, 200 kv., 1 mm. copper, 1 mm. aluminum, at 50 cm. distance. In several of these, this dose was repeated after four weeks. Mikulicz's syndrome will also respond temporarily to irradiation. The final outcome is, of course, dependent upon the particular disease with which it is associated.

Localized Infections especially on and about the Face. Probably the greatest usefulness of the roentgen ray in the treatment of potentially serious infections is in apparently more or less insignificant lesions which occur on the upper lip, around or within the nose, around the eyes and to a lesser extent on the extremities. Frequently, the primary portal of entry of the infection may be nothing more than a slight abrasion, cut, bruise or pimple. Where the infection is of sufficient virulence, there is a rapid lymphangitis and thrombophlebitis. Facial lesions, for in-

Fig. 17. Case IX. Subacute parotitis.

Fig. 18. Case IX. After irradiation.

Fig. 19. Case x. Girl two years old. Severe infection with cellulitis extending almost to the hip. This followed a slight burn on the lower leg. In spite of antistreptococcic serum the lesion continued to spread.

Fig. 20. Case x. Following irradiation the spread of the infection stopped. Her temperature came down within twelve hours and she went on to an uneventful recovery.

stance if nothing is done, not infrequently lead early to the vessels of the brain and a fatal termination.

The extremity portals of infection, if not controlled, frequently lead to a general septicemia. The entire medical profession must realize the possible seriousness of this type of infection if any headway is to be expected in its treatment. In tetanus, which is rather rare, the profession is wide awake and antitetanic serum is given routinely. The above type of infection is not so uncommon yet little is done about it.

In our experience, regardless of the insignificance of the primary portal of entry, when the slightest spread of the infection to the surrounding fixed tissues is noticed, 100 to 150 r, unfiltered low voltage roentgen rays should be applied. As a rule, there is a rapid walling off of the infection within from six to twelve hours. However, if there has not been definite improvement within

Fig. 21. Case xi. Marked cellulitis of left of face and neck with no tendency to clear up or break down after one week.

Fig. 22. Case xi. Never any suppuration but fairly rapid disappearance of the swelling and infection following irradiation.

Fig. 23. Case xii. Infection of upper lip, face and nose following slight abrasion close to the wing of the nose.

Fig. 24. Case xii. Within a few hours following irradiation there was a fairly heavy discharge of seropurulent material from the local lesion, with recovery.

twenty-four hours, a consultant experienced in bacteriology and immunology should be called in.

The majority of these infections are due to the streptococcus, especially the hemolytic type, and early in the infection antistreptococcic serum is of value. After there is a general septicemia, antistreptococcic serum and transfusions from an immunized or normal donor must be used. Here, however, there is a very serious infection of the

Fig. 25. Case xiii. Three days previously while shaving he cut a small place on the outer side of the upper lip. Within twenty-four hours the infection spread up over the face, nose and around the left eye. Temperature 102° F.

Fig. 26. Case xiii. Following irradiation the spread of the infection stopped and there was some discharge of a seropurulent type from the primary focus of infection. Photograph made five days later.

fixed tissues and of probably the blood itself with the usual barriers to infection broken down and regardless of the treatment the outcome is usually fatal. Naturally every radiologist who treats these infections should be familiar with the modern treatment of these conditions in order that he may not delay for one moment other treatment which may be very necessary and life saving. It is thoroughly realized that many of these infections are normally self-limiting. However, the successful treatment of a large number of such cases is strong evidence of the great value of the roentgen ray in the early stages.

In my experience, the surgeon, the internist and the immunologist have cooperated in every possible way with the radiologist. The radiologist must be absolutely certain that he is cognizant of the seriousness of these infections and that he in turn in every way possible cooperates with the other branches of medicine. Probably the day is not far distant when all of these infections will be seen by the radiologist the minute, day or night, that there is the slightest evidence of spread of the infection to the immediate surrounding fixed tissues and that a small dose of roentgen rays will be applied. Unless there is definite walling off of the infection and improvement within twelve to twenty-four hours, the immunologist will be called in and antistreptococcic or other serum administered, as antitetanic serum is today, before there is a general blood infection or septicemia. In this, and in no other way, until possibly when, and if, some substance which may sterilize the blood stream has been discovered, can we expect to lower the mortality in this not infrequent and deadly malady.

DISCUSSION

Irradiation is of definite value in the treatment of some other infections, for instance, sinusitis; but, in this presentation, only those conditions where this method seems, without reasonable doubt, to offer more than any other have been considered.

In carbuncles some still believe that other forms of treatment may give as good or possibly better results. This has not been my experience.

No other therapy will give results comparable to irradiation in furunculosis, parotitis, early localized infections, infected rhinophyma, ordinary and telangiectatic granuloma and Mikulicz's disease.

The radiologist has a method of therapy which has been proved, both experimentally and clinically, to be of great value in a number of infections; but many of them are doing little of this work. This is due entirely to the fact that the clinicians and the surgeons in their respective communities have not been familiarized with the work in this field.

Naturally the radiologist must be conservative and accurate in his statements if he is to obtain the confidence of the general profession who know little or nothing of the value of the roentgen ray and radium in the treatment of infections.

Some radiologists feel that they are being separated to some extent from the practice of clinical medicine. Here, there is a real opportunity, not only for service to the patient and referring physician but also for a wider experience in the practice of clinical medicine.

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THE ROENTGEN ASPECTS OF CHRONIC ARTHRITIS*

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THE great interest shown by the medical profession and the tremendous recent advances made in the study of arthritic conditions are true indications of the importance of this subject. It is therefore not surprising to find that the knowledge of pathology as interpreted by the roentgen ray has not kept pace with the advancing trend of research, until the roentgenologist has found himself confronted with such a bewildering array of problems and multiplicity of details that great confusion has resulted. This is well shown by the numerous classifications which have been used by the various authors. In our work, we have followed the classification adopted by the American Committee for the Control of Rheumatism, which is based on the pathology, and divides chronic arthritis into two general groups: atrophic and hypertrophic. We feel that joint changes due to specific etiological factors, such as syphilis, gonorrhea, pyogenic infections, trauma, gout and diseases of the central nervous system should be regarded under their own separate headings and that, from the roentgen standpoint at least, they should be differentiated, when possible, from that large group of cases which are now understood to represent chronic arthritis. The term chronic arthritis is therefore limited in our study to the so-called nonspecific variety, after the above-mentioned pathological conditions have been ruled out, as far as possible, by the clinical aspects of the case as well as from the roentgenographic evidence. An effort to resolve this confusion of isolated facts into some semblance of order and arrangement must necessarily follow along the line of the pathological observations, so far as roentgen interpretation is concerned. If we keep constantly in mind that the purpose of roentgen examination is to interpret pathological changes, and in dealing with the image of the lesion on the roentgenogram strictly recognize the limitations as well as the possibilities in this method, we are less likely to be led astray.

We have subdivided our group into two large general classes, those which show a predominance of hypertrophic signs and those which show the greatest degree of atrophic signs. This follows very closely the original pathological classification of Nichols and Richardson but these authors did not strictly limit their groups to the nonspecific variety. They included also under their headings various types of specific joint conditions. The proliferative group of Nichols and Richardson corresponds to the atrophic, rheumatoid, ankylosing, arthritis deformans and Still's disease; the degenerative group corresponds to the hypertrophic, osteoarthritic and non-ankylosing forms of other authors.

We can demonstrate with the roentgen ray only those processes which are sufficiently advanced to produce a recognizable change in the density and contrast of the tissues. As all early and acute signs of arthritis deal with the soft tissue structures, the only possible identification is by means of exceedingly soft radiation produced by very low voltages. Later in the process, when bone begins to show involvement, a more penetrating quality of radiation may be used to show the detail within the bone. We therefore strongly recommend making several exposures of the questionable joint, not only from different angles but also by varying the quality of the penetration to demonstrate all possible changes in both the bony and soft structures. Stereoscopic views are of definite advantage in many cases, especially in dealing with larger joints. We feel also

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that sufficient advantage is not taken of serial exposures. One of the greatest sources of usefulness of roentgen examination is in repeated studies at more or less regular intervals and a comparison of the progress or changes in appearance of the disease process. Very often the examination does not parallel the clinical observations and the assistance of studies at intervals, which are determined by the clinical course of the case, give considerably more information to guide the clinician than any single isolated observation. In considering the evidence, we have always sought to avoid reading clinical data into the roentgen interpretation, but many workers do not fully realize how important it is to have not only a clear and concise knowledge of the clinical aspects of the disease in mind when studying the films, but also the outstanding features of the particular case in question. If all phases are not carefully weighed and considered, one in relation to the other, the result is too often a report from the roentgen department which is not only of no direct assistance to the physician in charge but may be grossly misleading. Without a consideration of all possible phases of the case we have many times been puzzled as to whether we are dealing with true chronic arthritis, as previously defined, or one of the specific forms, and occasionally we have not been able to decide from the roentgen evidence alone whether the hypertrophic or atrophic variety is present. Every phase of the case must be separately considered but the final weight of evidence is the result of dovetailing each aspect into the other. The clinical features necessarily influence the final opinion of the roentgenologist. Many cases indeed do not show typical features of either type entirely consistent throughout, and to sift out the weight of evidence in an individual case requires the finest type of judgment from both the clinical and roentgenological viewpoints. There is a question at the present time as to whether these two processes are really separate and distinct entities or whether they may not arise from a common underlying etiological cause. It is also impossible at this time to state definitely which varieties of the arthritides are precipitated by underlying infection and which are not. Cecil, Nichols and Stainsby have reported high percentages of positive cultures from the blood and joints of chronic arthritic patients; other authors failed to confirm these findings in most cases. It is quite generally accepted, however, that underlying focal infection does play a large rôle in the etiology, but just how much other conditions of metabolism, body chemistry and changes incident to senility may be responsible is difficult to estimate. Therefore classification of the disease from the etiological standpoint, such as found in the writings of Umber, Goldthwait, Benekes, Hench and others, or from purely one or the other aspects of the disease only, does not meet the requirements for the roentgenologist, and it is better for him to consider only whatever difference can be shown by means of the roentgen ray. Nichols and Richardson do not attempt to decide this question but recognize the possibility that by arbitrarily separating them on the basis of the pathological features, other important phases may be overlooked. As pointed out by Osgood and others, we cannot say that both processes do not occur simultaneously in the same patient or even in the same joint. The degree of confusion can be readily understood, especially in the case of those roentgenologists who do not have the opportunity of reviewing large groups of cases. We cannot too strongly advise not only the closest cooperation between the clinician and the roentgenologist but the careful review of any available clinical data and the personal examination of the patient by the roentgenologist, himself, wherever it is possible. Many clinicians are misled by the belief that the roentgenologist should be guided solely by those changes which he can see on the roentgenogram. We hope to show in the following pages that nothing

could be more conducive to confusion and dissatisfaction. The roentgen examination, to be satisfactory, should, of course, be regarded in exactly the same manner as any other consultation between departments and personal discussion is often the most valuable feature of this type of cooperation. However, one of the greatest sources of confusion is the attempt on the part of the roentgenologist to assume the responsibility of interpretation without a clear and concise understanding of the underlying pathological principles. This understanding or background of pathology is the fundamental basis of all diagnosis, but assumes even greater importance than usual in the field of bone and joint disease. The roentgen evidence is the visible but incomplete expression of those changes which are actually taking place. The roentgenologist must therefore be intimately familiar with the pathology before he undertakes to interpret the evidence of that pathology.

For the general understanding of the problem, it is well to review briefly the main points generally recognized in the etiology of chronic arthritis. There is undoubtedly some basal, hereditary or constitutional factor which predisposes the individual to this disease. There can usually be traced certain influencing factors such as mental or physical fatigue, dietary indiscretions, organic dysfunction, especially of the gastrointestinal tract, exposure to cold or damp, and possibly what we regard as congenital weakness of the nervous system. Foci of infection undoubtedly play a great rôle. The above factors lead to various types of toxemia, and demands are made on the bodily reserves to combat these toxins. There is undoubtedly a vicious cycle established, the progress of the lesion reflecting itself back on the general condition of the body as a whole and especially the vital organs. The general tendency of both forms is downward, often with long periods of remission, until the joints have become splinted by natural processes with partial relief of symptoms. We find impairment of the gastrointestinal tract, circulatory function, closure of capillaries resulting in cold hands and feet, sympathetic nervous disturbances and invasion of these tissues of weakened resistance by bacteria.

A clinical differentiation must also be considered constantly in studying the roentgen features. The main points to be remembered in considering the atrophic variety are as follows: Patients will usually show the initial symptoms before the age of forty and very often in early youth. The onset is in many cases rather abrupt and may at first be considered a rheumatic fever, with increase in temperature local swelling about the joints involved and the usual symptoms of constitutional reaction. There is severe pain and limitation of motion due to inflammatory reaction. As a rule, the phalangeal joints are the first affected, or the knees. The muscles show early and marked atrophic changes. Atrophic arthritis may have the characteristics of acute rheumatic fever in that there is often a decided tendency to involvement of first one joint then another, by swelling, redness, heat and pain. Very often the patients are nervously depleted or physically below par, and most authors regard the slender ptotic type especially prone to the atrophic variety. It is common to obtain a history of circulatory disturbances, especially coldness of the hands and feet, previous to the onset of arthritic symptoms. Anemia, myalgia and neuritis are frequently associated symptoms, and fatigue is almost universal. The patient may have gone through several similar attacks before roentgen examination is requested.

The hypertrophic variety, as a rule, is not seen before middle life. The onset is usually gradual unless some slight trauma or strain has occurred to suddenly call the patient's attention to the condition. Vague pains, which may or may not be localized to a single joint, stiffness and sometimes sharp stabbing pains on certain motions may be ignored for many years before the patient seeks medical advice. This variety

often goes through a stage of acute symptoms, but is somewhat less likely to than the atrophic form, and there is often a complete lack of any history indicating local swelling and heat. There is usually no marked constitutional reaction and the general health may not be disturbed to the patient's knowledge. The pain and limitation of motion are the first symptoms which usually bring the patient to his doctor, and these are regarded by the patient as a result of trauma rather than spontaneous in origin. The distal phalanges are often the first to become involved and nodular swellings may be present for many years before the patient realizes that there is any general condition present. The muscles show atrophy only in the late stage, as the lameness gradually increases. No history can be obtained of recurrent attacks simulating acute rheumatic fever in the large majority of pure hypertrophic cases. It is as commonly seen in the well-nourished type as in the feeble. There is little or no constitutional disturbance, and prodromal symptoms of a circulatory nature, such as cold hands and feet, are less likely to be mentioned than in the atrophic form.

Many authors have discussed the roentgenological aspect of chronic arthritis from various points of view. The knowledge of its presence in paleolithic man and the certainty of the condition antedating the human race is discussed by Osborne and Pemberton. Evidences of arthritic changes have been found by roentgen examination of ancient specimens. Moore states that a number of conditions simulate arthritic processes, and in an analysis of 10,509 cases finds that a tentative diagnosis of arthritis in some form was made in approximately 4.5 per cent. He also points out that in a large majority of the cases in which roentgen signs of arthritis were found it was unsuspected until the films were reported on. Vanzant, in a study of 100 cases each of rheumatic fever, arthritis and gout, has found that many of the cases in the early stage cannot be differentiated from each other. Painter regrets that there is so little knowledge of the pathology from the surgical standpoint, as only seldom does the occasion arise in which an arthritic joint is opened during the early stage of the disease. Thus our knowledge from the roentgen standpoint must be collected by reviews of large numbers of cases. An estimation of the true value of roentgenography in arthritic conditions will eventually be the result. One of the greatest advantages of roentgen examination is to eliminate other factors, such as bone disease, tumors, trauma, etc., which may easily confuse the clinical picture. Shanks states that in pure soft tissue lesions the roentgen evidence is negative, but we have found considerable advantage in exposing some plates especially for soft tissue and believe that in the future this will be of decided value. Munk and Muncke rely on roentgen findings for differential diagnosis in early stages but in their writings do not especially stress the importance of soft radiation. Mueller concludes that it is often impossible in many cases to make a correct diagnosis, even after clinical examination, roentgen picture and pathologico-anatomical study of the joint removed by operation, unless serial examinations are made over a fairly long period of time. Krebs states that although roentgen examination furnishes valuable information, the films are often deceiving and many a symptom which is not present is read into them. Scott concludes from his work in the British Red Cross Clinic for Rheumatic Diseases that the changes shown in the hand and wrist frequently supply the key to the type of arthritis and uses a routine study of hands as his basic factor for diagnosis in cases where the major joints are not sufficiently typical to be conclusive. Kienböck stresses the importance of clinical knowledge of the cases associated with the roentgenologic findings before diagnosis is attempted. He also states that the opinion of the patient as to the onset of symptoms following accident, exertion or infectious disease is frequently

false and that the roentgenogram often reveals an affection of longer standing. Pemberton points out very strongly the depleted condition of the system generally in large groups of arthritic patients, with lowering of the metabolic rate, delayed glucose tolerance, slowing of capillary circulation, lowering of temperature in affected parts, and lowering of the general constitutional resistance. Most authors, who have discussed chronic arthritis from a pathological standpoint, refer back to the outstanding work of Nichols and Richardson in 1909, which forms the basis of our outline of pathology and from which we have attempted to build the general structure of roentgen interpretation.

With the above ideas as a background, we sought to collect a series of cases for analysis, using the routine material which came to the Roentgen Department of the Presbyterian Hospital, Philadelphia, largely through the services of Dr. Ralph Pemberton and his associates. The accompanying table is not intended in any manner to represent a statistical study, as we made a definite selection from approximately 2,500 cases between the years of 1923 and 1932. This selection was intended to gather together especially material in the earlier stages, and also to represent as far as possible an even distribution of cases in the various degrees of severity. Therefore, it is impossible to base percentages on the above figures for statistical purposes. The number of hypertrophic cases in the usual course of routine roentgen studies would be decidedly higher on a percentage basis than we have shown. Furthermore, as the study was made partially from cases admitted to the hospital wards, it was soon discovered that there was a greater percentage of atrophic cases admitted, the ratio being about 10 of atrophics to 1 of hypertrophics. In reviewing the cases a rough attempt was made to subdivide them from the roentgen findings into early, moderate and advanced stages, but as this was done before the clinical records were fully analyzed and comparisons made, it is only a very rough approximation. The figures are given, however, to show the number and approximate material available for study. Reference is made to an article by Pemberton and Peirce, who made statistical studies of 1,100 cases and found that twice as many women suffered from arthritic conditions as men. The greatest incidence of involvement in males was between thirty-six and forty years of age, whereas in women it was between forty-one and fifty. Our studies show almost equal numbers of males and females and although most of our cases fell within the general age limit of thirty to fifty, our youngest patient was four years of age and our oldest eighty-four. Although our cases were intended to represent a fairly even distribution of material, it will be seen that we could only identify one case as typical of an early hypertrophic condition occurring in the wrist of a male subject. Other discrepancies appear in the analysis of the figures, and for this reason we wish to emphasize the fact that they are only intended to indicate the actual material analyses. Those classes of cases which show hypertrophic changes without symptoms were excluded from our series. If these had been included, it would have increased the proportion of hypertrophic cases tremendously. It is important, however, to consider these changes which are seen with advancing years, as they are so universally present. They can be regarded as definitely "arthritic" and any deviation from normal must be mentioned, but they are without symptoms, and we arbitrarily relegated this group to a class which we called "potential arthritics." This includes most persons past the third decade in which capsular thickening, spur formation or changes in the calcium distribution about the joint vicinity are demonstrated. In practically all of these subjects slight trauma or other unusual distress will cause pain entirely out of proportion to the exciting agent, and on roentgen examination large spur formations with irregularities

may be clearly demonstrated, evidently present for many years previously. This silent stage or condition of potential arthritis was rigidly excluded from our group as far as possible.

THE NORMAL JOINT

To aid the understanding of changes produced by disease processes, it is important to bear in mind the normal structure of the joint and surrounding area. If we take as a simple illustration one of the adult phalangeal joints where only two bones articulate together, the various structural layers are as follows (Fig. 1). The articulating end of each bone is capped by cartilage which in turn is covered with a thin layer of perichondrium. The perichondrium becomes continuous at the edges of the cartilage with the synovial membrane. The cartilage near the joint surface is composed of a relatively dense hyaline matrix with a few small scattered cells, but as the deeper portion is reached these cells become larger, more numerous and arrange themselves in rough columnar formations. In the deepest portion the cells are distinctly hypertrophied. A very narrow granular zone lies just beneath the cartilage and here we find mainly bone corpuscles mixed with the cartilage cells surrounded by a matrix of lime deposit. This is the layer of transition from cartilage to bone and is often referred to as the zone of temporary or provisional calcification. Below this zone are found marrow spaces, with high degree of vascularity, and the spongy or trabeculated bone proper. The synovial membrane is a thin connective tissue layer lining the inner surface of the joint capsule not covering cartilage but continuous with the perichondrium. In places it is folded inward forming fringes or plicae. The joint capsule is a tough fibrous supporting structure, continuous at its insertion with the periosteum near the border of articular cartilage. The ligaments and surrounding muscle insertions vary with the individual joint and reference must be made to the standard texts of anatomy for description (Fig. 1).

Many of these structures are not directly visualized on the roentgenogram, and pathological changes occurring in them must be indirectly judged by those changes which we are able to show in the structures of sufficient density to produce contrast on the roentgen film. The perichondrium and cartilage are not seen without air insufflation, the width of the joint space and its clarity being the only guide to pathology occurring in this region. The capsule and synovial membrane likewise are not visualized on the usual film, but may be brought out by very soft rays in the larger joints. The zone of temporary calcification is shown as a dense band, being the first line of contrast proximal to the joint space. The spongy bone, cortex and medulla are

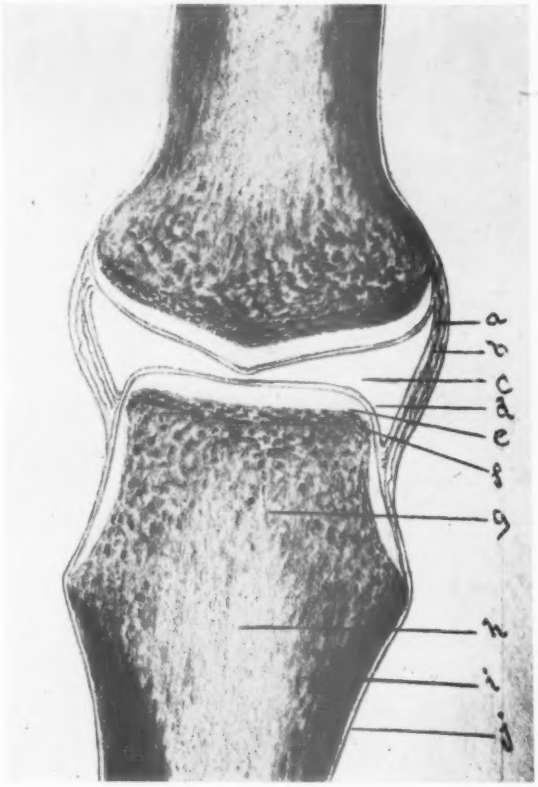

Fig. 1. *Normal joint.* Diagram of a simple joint in which two bone ends covered by their cartilage articulate, as in the phalangeal joints. *a*—synovial membrane, *b*—joint capsule, *c*—joint space, *d*—perichondrium, *e*—joint cartilage, *f*—zone of provisional calcification, *g*—spongy bone, *h*—medulla, *i*—cortex, *j*—periosteum.

well visualized and differentiated. Surrounding soft tissues are faintly but clearly outlined and gross swelling can be determined (Fig. 2).

Fig. 2. Roentgenogram of phalangeal joints. The synovial membrane, joint capsule, perichondrium and cartilage are not visible in the roentgenogram. Note the band of increased density in the base of the phalangeal joints, indicating the zone of provisional calcification. It is absent in the heads of the phalanges as the trabeculated bone extends to the joint cartilage.

For the sake of simplicity in visualizing the recognized pathological changes which commonly occur in the two groups of chronic arthritis, let us review them, briefly mentioning the various processes which take place simultaneously, but in attempting to arrange them in sequence it must be borne in mind that one type of change may so overshadow the others that varied and complicated pictures are produced as end-results. For more extensive descriptions of pathology the reader is referred to the texts and excellent monographs on the subject; we have only attempted here to briefly outline those phases which are of direct importance in the interpretation of roentgenograms. It is also important to bear in mind that the disease process may be arrested at any stage and remain stationary. A return to normal after the very early stage has been passed is not recognized and once the bone has become involved, evidence of the disease will persist, even though the case may clinically show great improvement or complete disappearance of symptoms. Thus we may have the characteristics of the early or initial stage many years after the onset of symptoms. The pathological changes interpreted on the roentgenogram we have divided into early, intermediate and advanced. This is done merely as a convenient method of appraising the degree of severity from our own standpoint. We may, judging from the roentgenographic evidence, consider a case to be in the advanced stage, whereas the clinical aspects may indicate that it is of only a few weeks' or months' duration. This would mean that the pathological process has been advancing for a long period of time previous to the onset of clinical symptoms. In other cases we have often found that little evidence is present in cases where the history indicates a very long duration. This finding signifies that there have probably been many exacerbations and remissions of the symptoms without a parallel degree of damage to the actual joint structures. Comparisons of this nature are of the utmost value to the clinician and are frequently of more marked significance when the roentgenographic and clinical evidence do not agree than in those cases where the roentgen findings confirm the changes which the clinician obtains on physical examination.

THE VERY EARLY STAGE

The acute joint or very early stage may be described as showing a slight increase in width of the joint space, due to excess of fluid content, bulging of the capsule and thickening of the periarticular soft structures. We have been able to demonstrate no absolutely characteristic change to designate any individual form of arthritis at this period, as these features are common to the joints of acute rheumatic fever and nearly all of the so-called specific arthritides during their active or initial

stages. Some varieties, however, especially where the hypertrophic features predominate, do not necessarily show these changes and may or may not pass through this stage.

ATROPHIC ARTHRITIS—EARLY STAGE

The early stage (Fig. 3) of atrophic arthritis presents in a general way the following course: The synovial membrane becomes actively proliferating and spreads inward over the surfaces of the cartilages in a thin layer of granulations. This, by growing inward from the joint margins, forms a surface covering or pannus, which gradually tends to extend more or less completely throughout the joint space. Destruction results wherever this pannus spreads in intimate contact with the cartilage and the underlying cartilage cells are absorbed. Wherever destruction is not being caused by the pannus the perichondrium proliferates simultaneously to form irregular areas of new cartilage. This causes an unevenness of the joint surfaces and closer proximity of the bone ends. The capsule of the joint is also thickened at this stage by the addition of vascular connective tissue, which later becomes fibrous. There are changes taking place within the bone structure at the same time. There is an active proliferation of the connective tissue cells lining the marrow spaces which forms loops of granulation tissue. These masses penetrate through the zone of provisional calcification and destroy the cartilage from below. Within the bony trabeculae there are two simultaneous processes taking place. There is an unusual activity of the osteoblastic elements, which tend to lay down irregular trabeculae of new bone and a similar stimulation of osteoclastic elements which destroy small areas in the trabeculae. Thus we can visualize the early stage of the process as being a response to some abnormal stimulation and the general features of it as characterized by overgrowth of all of the soft tissue elements entering into the joint composition.

The first recognizable roentgenologic change which led us to be suspicious that this joint might be in the class of atrophic arthritis was a roughening or slight irregularity along the surface of the bone, which is capped by the articular cartilage. This zone of provisional calcification begins to show changes which are not of themselves characteristic but which appear to be an active proliferation of some of the elements. There are very minute projections of new bone into the cartilage and small irregular areas of decreased density, especially on the proximal border. This is due to the early activity of the proliferating

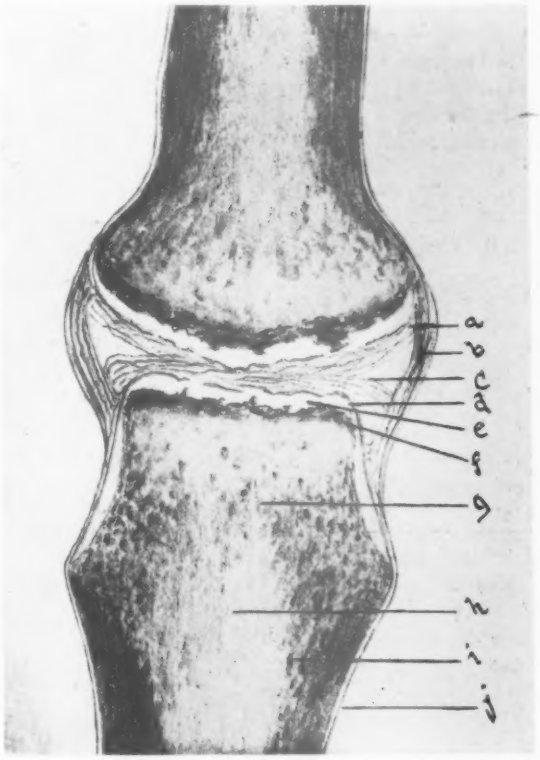

FIG. 3. *Atrophic arthritis—early stage.* Diagrammatic illustration of pathological changes in early atrophic arthritis. *a*—proliferation of synovial membrane to form a pannus, *b*—thickening of joint capsule, *c*—joint space partially filled by ingrowth of pannus, *d*—irregular destruction and proliferation of perichondrium, *e*—erosion of cartilage by the synovial pannus, *f*—irregularity of line of provisional calcification due to ingrowth of capillary loops, *g*—atrophy of spongy bone, *h*, *i*, *j*—unchanged.

STATISTICAL STUDY OF 1,000 CASES OF CHRONIC ARTHRITIS
AGE 9–76 YEARS

	Males			Females	
	Atrophic	Hypertrophic		Atrophic	Hypertrophic
Hand and wrist	21	37	Hand and wrist	65	26
Elbow	26	32	Elbow	17	13
Shoulder	20	45	Shoulder	25	25
Foot and ankle	25	83	Foot and ankle	54	45
Knee	79	92	Knee	101	93
Hip	14	15	Hip	25	20
Total	187	304		287	222

	Males					
	Atrophic			Hypertrophic		
	Early	Intermediate	Advanced	Early	Intermediate	Advanced
Hand and wrist	5	12	4	11	10	16
Elbow	6	12	8	18	6	8
Shoulder	3	7	10	11	14	20
Foot and ankle	8	13	4	29	31	23
Knee	27	33	19	31	41	20
Hip	4	4	6	8	5	2

	Females					
	Atrophic			Hypertrophic		
	Early	Intermediate	Advanced	Early	Intermediate	Advanced
Hand and wrist	18	27	20	1	13	12
Elbow	6	6	5	4	5	4
Shoulder	8	9	8	13	7	5
Foot and ankle	24	24	6	28	7	10
Knee	36	56	9	29	41	21
Hip	8	8	9	5	6	9

loops of granulation tissue and formation of new bone in the vicinity of the zone of provisional calcification. This faint suggestion of irregularity is usually seen very early; in some cases it is associated with more or less fusiform swelling of the periarticular tissues and the joint space may be wider than usual; in other cases, seen at a slightly later stage, the joint space may be narrowed somewhat as a result of an early destruction of cartilage by the synovial pannus. There is often a rather homogeneous haziness between the bone ends due to the filling in of the space by newly formed soft tissue. This appearance is most marked, of course, in the larger joints and is best seen on films made for soft tissue differentiation, but it is often

ATROPHIC ARTHRITIS PROLIFERATIVE RHEUMATOID

Changes in Joints

- Synovial membrane—proliferation
  - Pannus
    - fibrous—less obliteration, less adhesions, more motion
    - vascular—cartilage destruction, bone denuded of cartilage, but covered with granulation or fibrous tissue—fibrous adhesions—fibrous ankylosis
  - Adhesions—bands to the cartilage—dividing joint space
  - Tags—often contain
    - fat
    - cartilage—break off—joint mice
- Cartilage
  - destruction (synovial pannus)
  - proliferation of cartilage from perichondrium—new bone formation
- Capsule—proliferation—vascular connective tissue—fibrous thickening
- Perichondrium—proliferation—fibrous tissue—new cartilage—new bone

Changes in Bones

- Marrow spaces—proliferation—granulation tissue—capillary loops—penetrates and destroys
  - lymphoid cells
  - plasma cells
  - osteoclasts
  - zone of provisional calcification
  - cartilage—coalesces with synovial pannus
- New bone trabeculae—narrowing of marrow spaces—dense bone (osteoblasts)
- Endosteum—proliferative—penetrates with granulation tissue into cartilage. New bone adheres to similar process from other side of joint. Bony ankylosis—obliterates joint space—marrow space becomes continuous at epiphyseal margin of articular surface—spur formation
- Shaft—early absorption calcium salts—no atrophy

HYPERTROPHIC ARTHRITIS DEGENERATIVE OSTEOARTHRITIS

Changes in Joints

- Synovial membrane—irregular proliferation
  - sessile
  - pedunculated—contain
    - fat
    - cartilage
    - bone—break off—joint mice
- Capsule
  - normal or slight thickening
  - marked thickening—fibrous
    - cartilage deposit
    - bone deposit
- Cartilage—softens and fibrillates
  - irregular—erosion—peels off and dissolves
  - complete erosion—bone denuded—two bony surfaces articulate
- Perichondrium—proliferates
  - irregular—to fill spaces on opposite side
  - synovial attachment
    - fibrous—cartilage—bone—(Heberden's nodes)
    - direct outgrowth—cartilage—bone
      - spurs and irregularities

Changes in Bones

- Marrow spaces—narrow or obliterated—irregular cystic formation by osteoclast. Thickening of zone of provisional calcification—new bone formation in joint cartilage—irregular articular surfaces—luxation and distortions.
- Endosteum—proliferation
  - widening of circumference just proximal to joint space
  - eburnation of bone proximal to joint space.
- Shaft—absorption—secondary to disuse

fairly well visualized in the smaller joints where the films are of good technical quality. Simultaneously with the above changes, we begin to notice that there is a narrow but definite zone of rarefaction within the trabeculated bone, beginning just proximal to the zone of increased density or provisional calcification. The recognition of this atrophy, as being associated with the above described finding, is prob-

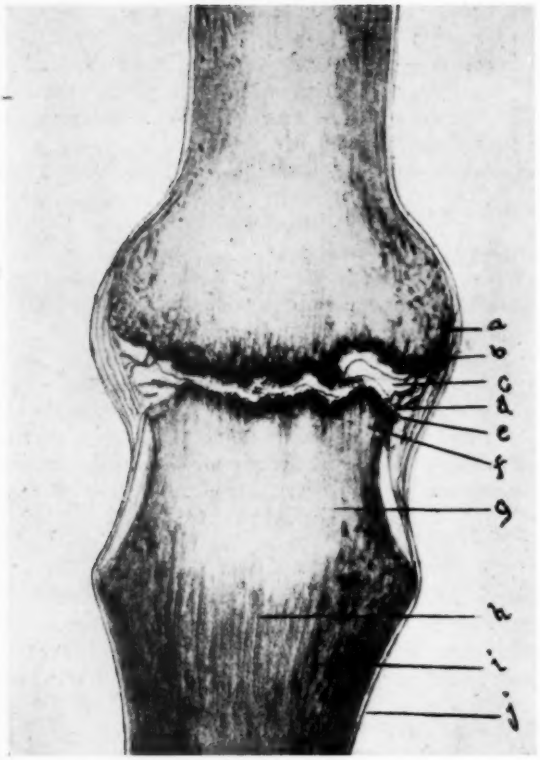

Fig. 4. *Atrophic arthritis—intermediate stage.* Diagram of intermediate stage. *a*—synovial membrane disappeared as it has proliferated into the pannus, *b*—joint capsule thickened, *c*—joint space almost completely obliterated and crossed by bands of fibrous adhesions, *d*, *e*—gross irregularity of cartilage which has fused with opposite cartilage but fragments are still preserved, *f*—gross irregularity of zone of provisional calcification, *g*—increased atrophy of spongy bone, *h*, *i*, *j*—unchanged.

ably the earliest sign which would lead us to regard the changes as characteristic in any degree of atrophic arthritis. The rarefied area extends proximal, very shortly involving a large portion of the broadened trabeculated end of the bone. This is regarded, as above stated, as a pathological withdrawal of calcium salts rather than a simple atrophy of disuse. It causes more or less of a fairly characteristic ground glass appearance through which the bone trabeculae are visualized and appear rather hazy in contradistinction to the usual type of atrophy where the bone has been splinted for a short period of time and in which the trabeculae stand out clearly. The upper borders of the atrophy shade off very gradually into the surrounding density of the bone and even when it has progressed to a fairly marked stage there is no distinct demarcation. Occasionally a small spicule will form at the joint margin, which represents calcium deposit where the synovial membrane joins the cartilage. This is, in some cases, confused with the early spur formation in the hypertrophic variety but by considering the associated signs also, we are not often led astray. The atrophy in the terminal end of the bones, by lying in close relation to the dense zone of provisional calcification, causes this lateral area to stand out in much greater contrast than is usual in

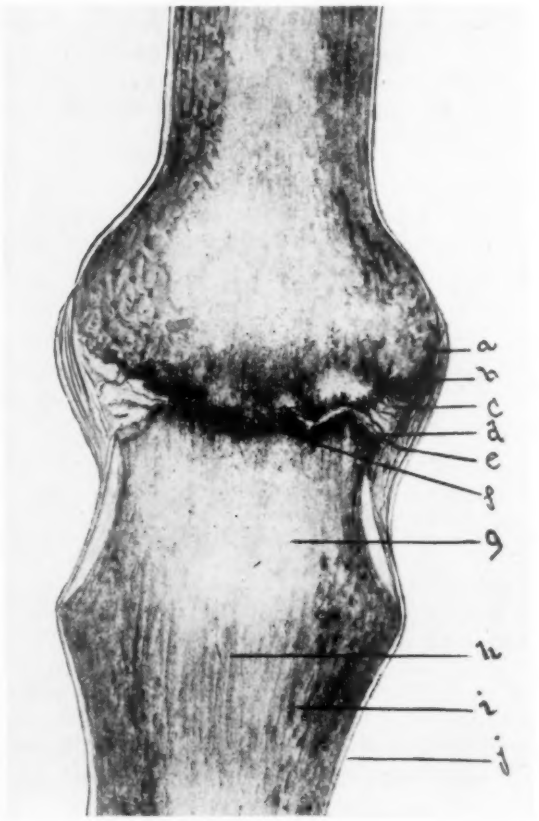

Fig. 5. *Atrophic arthritis—intermediate stage.* Diagram of intermediate stage. *a*, *b*, *c*, *d*, *e*—only traces of original structures remain, dense adhesions are present, *f*—fusion of the zones of provisional calcifications causing bony ankylosis, *g*—atrophy of spongy bone, *h*, *i*—secondary atrophy in shaft.

normal bones. As the synovial pannus continues its destructive work the joint space becomes more narrow and the two ends of the bone approximate closer together. In summarizing the early stage we would regard the typical roentgen appearance as being the following (Figs. 8 and 9):

1. Rarefaction of the trabeculated ends of the bones.
2. Preservation of the zone of provisional calcification.
3. Irregularities of the above zone.
4. Homogeneous haziness throughout the joint space.
5. Widening at first and later narrowing of the joint space.

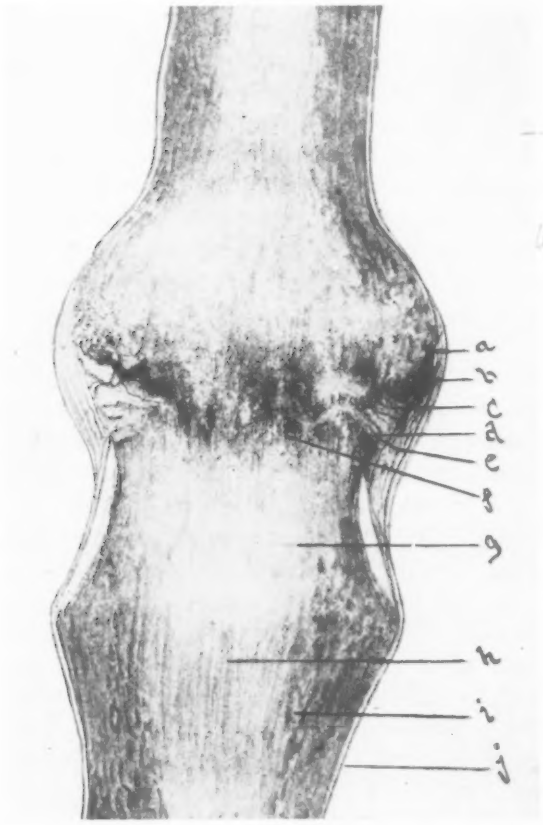

Fig. 6. *Atrophic arthritis—advanced stage.* Diagram of advanced stage. *a*, *b*, *c*, *d*, *e*—very little of original structures can be identified, adhesive bands present, small cartilage and spicules of calcium deposits about joint borders, *f*—firm union with irregular remnants of zone of provisional calcification, irregular areas of atrophy, *g*, *h*, *i*—some slight secondary atrophy.

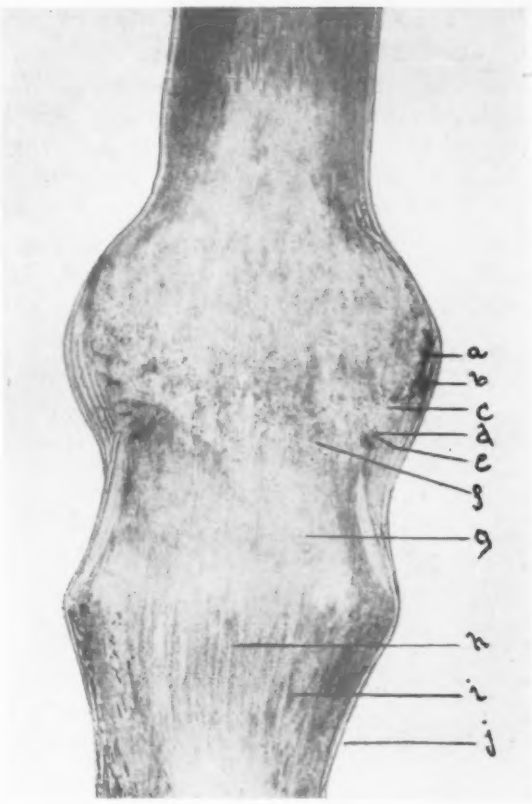

Fig. 7. *Atrophic arthritis—advanced stage.* Diagram of advanced stage. *a*, *b*, *c*, *d*, *e*—same as previous, *f*—solid bony fusion, continuation of spongy bone, fragmentary remains of zone of provisional calcification, a few small discrete areas of atrophy locally, *g*, *h*, *i*—widespread secondary atrophy throughout.

6. Fusiform swelling of the soft tissues generally, especially about the immediate vicinity of the joint.
7. Occasionally small spicules of calcium deposits about the joint margins.

ATROPHIC ARTHRITIS—INTERMEDIATE STAGE

As the processes approach the intermediate stage (Figs. 4 and 5) all the above changes gradually progress until we find the capsule and synovial membrane greatly thickened, and often thrown inward into folds or plicae. Sometimes within these pouchings cartilage will be formed which later ossifies or accumulates calcium deposit and may occasionally break off to form small free bodies or "joint mice."

Very often fine adhesive bands will form between the thickened synovial membrane and the denuded joint cartilage. These bands become firmer by the addition of fibrous tissue until the joint space is partitioned off into separate compartments. In places two denuded surfaces of cartilage may fuse and in other places the synovial pannus fills in the entire joint. The result is marked limitation in motion due

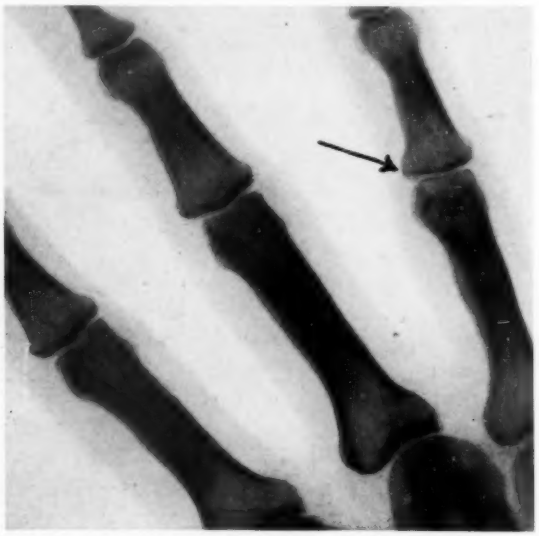

Fig. 8. Slight fusiform swelling of soft tissues and thickening of periarticular tissues about midphalangeal joints. Haziness of joint spaces, slight roughening of zone of provisional calcification and atrophy of the spongy bone proximal to the joint region. Early stage atrophic arthritis (see Fig. 3). Most characteristic joint indicated by arrow.

to the fibrous and soft tissue ankylosis. There is often a tendency to greater thickening on one side than on the other, with a resulting slipping of the bone ends. This is quite typical in the metacarpophalangeal joints in which all of the phalanges are deviated to the ulnar side. It is seen more rarely in the large joints. The erosion of the cartilage from above by the synovial pannus and from below by the penetrating loops of granulations in time completely perforates through irregular areas of the articular surface of the cartilage. As these granulations progress in their destructive action, they are backed up by new bone formation and cause the original smoothly rounded zone of provisional calcification to become grossly irregular. The attempt of the perichondrium to compensate by forming new islands of cartilage eventually fails, and as the destruction continues two newly formed areas of osseous tissue come in contact. These very readily fuse and form bony ankylosis. If the joint is opened at this stage a striking and composite picture is presented to the surgeon. There are irregular areas of cartilage remaining, sometimes large nodules on one joint surface have formed to compensate for a destruction of the corresponding opposite cartilage surface. In places there is fusion between the layers and very large or small irregular areas will break off. Usually the cartilage is best preserved about the periphery and the greatest degree of destruction is more likely to be central. This is due to the better circulatory supply at the periphery. Partial irregular areas of ossification are apparent on the exposed joint surfaces and in attempting to force the joint a crackling is noticed, which is the breaking up of the small areas of ankylosis. There is simultaneously a withdrawal of calcium salts proximal to the zone of provisional calcification, the exact mechanism of which is not thoroughly understood at this time, but it is in most cases more marked than we usually expect to find from simple atrophy of disuse. This begins in the distal end and gradually progresses upward into the shaft. When the intermediate stage has been reached advanced clinical symptoms are already apparent. The motion of the joint is usually limited or firm ankylosis has begun. Very often the acute symptoms have subsided and the pain, edema and considerable amount of the swelling disappear. There is also associated marked atrophy of the muscles in the vicinity.

On roentgen examination we are likely to find less generalized fusiform swelling of the soft tissues but the ligaments of the joint capsule and tissues in the immediate neighborhood show marked thickening,

which is readily seen on the roentgenogram. This, in all cases, coincides with the doughy feeling, which is described by the clinician, surrounding these joints and is distinctly different in appearance from the generalized edematous type of swelling of the early stage, as it is limited to the immediate vicinity of the joint proper. This is due to the increase in thickening and deposit of fibrous tissue in the capsule itself. The bony ends are more closely approximated and the irregularity of the zone of provisional calcification becomes quite marked. In some places proliferating loops of granulations break through the zone of provisional calcification, causing its complete disappearance in more or less irregular areas, and on the roentgenogram we see a broken and very much thinned line of density. Eventually the bone ends come into actual contact and in places the two zones of provisional calcification fuse; in other places there will still be small gaps remaining between them, which represent the islands of cartilage not yet absorbed. Bony ankylosis gradually but progressively results and as the process advances all remaining spaces are completely filled in by osseous material. We now see a single irregular line of increased density in place of the former joint space. Before this stage has been reached, there will often be a slipping of one bone on the other so that when fusion occurs the original alignment is distorted to a marked degree. As previously described, the earliest deviation of this type is in the metacarpophalangeal joints, where the deviation of the phalanges to the ulnar side is quite common. However, the toes may be deviated in a similar manner. The tendency, in a general way, appears to be fixation in a more or less flexed position. This occurs first in the smaller joints but is also later observed in the larger and more complicated joint structures, especially hips, knees, elbows and wrists. The spur formations along the synovial attachments are in almost all cases smaller than the similar spurs which are formed in the hypertrophic variety. The former are composed usually of calcium deposit, which, although mottled, show a different pattern than true bony spur formation and in many cases it is possible to differentiate the spicules of atrophic arthritis from the bony spur formation of hypertrophic arthritis by the density and general lack of bone structure. The atrophy in the proximal portion of the shaft becomes very

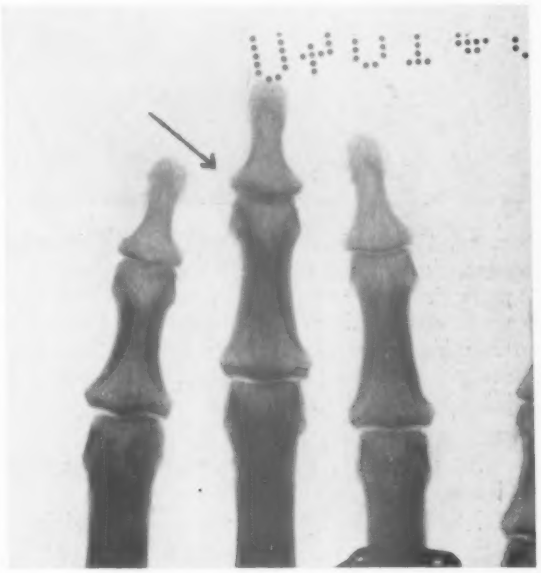

Fig. 9. Case VIII. Narrowing of joint spaces, increase of atrophy and increase of irregularity of the zone of provisional calcification. This roentgen appearance indicates a stage between Figures 3 and 4. Most characteristic joint indicated by arrow.

well marked but still retains more or less of the ground glass character. It progresses upward into the shaft and, as the splinting of the bone by means of ankylosis advances, the shaft usually begins to show the secondary or disuse type of atrophy, until the entire bone becomes distinctly atrophic throughout. As the intermediate stage is reached the appearance becomes more and more characteristic. In summarizing the roentgen appearance at this stage we would note the following points (Figs. 10 and 11):

1. Atrophy involving the entire bone ends and advancing into the shaft, presenting a ground glass appearance associated later

Fig. 10. Case 1. Further increase of the atrophy, narrowing of joint spaces, marked thickening of periarticular tissues, marked irregularity of the zones of provisional calcification. No atrophy of the midportions of the shafts. Intermediate stage atrophic arthritis (see Fig. 4). Most characteristic joint indicated by arrow.

with secondary disuse atrophy of the shaft itself.

2. Gross irregularity of the zone of provisional calcification with narrowing and destruction in small areas.
3. Contact of two adjacent zones at various points with preservation of the lighter areas, which indicate unabsorbed cartilage islands.
4. Complete fusion of the zones forming a single line of increased density.
5. All remains of joint structure are now obliterated and firm ankylosis of the bones results.
6. Thickening of the periarticular tissues in the immediate vicinity of the joint.
7. Small calcium deposits about the joint margins, which can often be differentiated from bony spurs.

ATROPHIC ARTHRITIS—LATE STAGE

When the late stage (Figs. 6 and 7) is reached erosion of the cartilage has progressed to such an extent that only a few scattered traces remain. The tendency of the new bone formation to fuse and obliterate the joint surface gradually and steadily continues, replacing the synovial pannus and the fibrous bands of adhesions, all of which completely disappear. Even the zone of provisional calcification may fuse into a homogeneous cancellous structure, which is continuous throughout, and gives the appearance of a single layer of bone except at the margins, where more or less contour of the original joint is preserved. However, while these changes are taking place, we often observe fairly well-marked irregular areas of destruction, which resemble in a general way the typical "punched out" areas about the margins of a gouty joint, in which the bone detail has been partially or completely dissolved and the cavitation is filled in with a gelatinous material. The mechanism of this type of destruction is not clearly understood.

The previously thickened capsule becomes firmly stretched over the surface of the bone and calcium salts may be deposited throughout, causing a very rigid sheath which is impossible to separate from the cortex of the bone. After all the

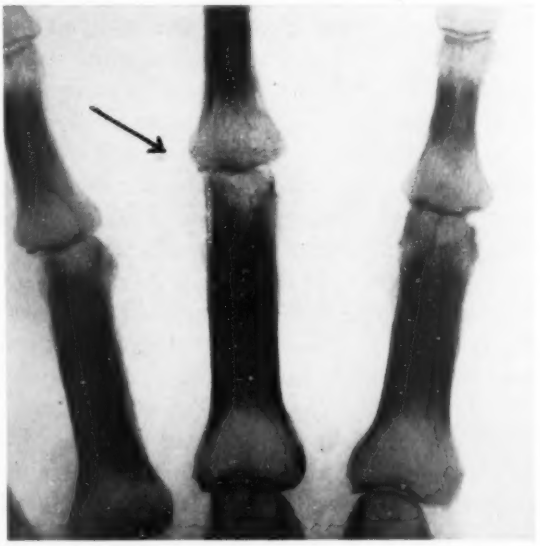

Fig. 11. Marked atrophy, gross irregularity of the zones of provisional calcification, early ankylosis, periarticular thickening. Attention is especially called to the "ground glass" character of this atrophy as compared with that of a similar stage in hypertrophic arthritis. Intermediate stage atrophic arthritis (see Fig. 5). Most characteristic joint indicated by arrow.

existing structural components of the joints have been entirely obliterated, there is a peculiar tendency in nature to actually attempt the construction of a single bony shaft. We find the marrow structures extending distally until eventually they are fused and a single uniform marrow space may be present surrounded by well-formed cortex. It is often difficult to believe that the previous complicated construction of the joint had ever existed. Advanced generalized atrophy is usually present throughout, which is due to disuse as well as to the above described pathological tendency of calcium withdrawal. Almost always as a rule when this stage is reached, all clinical symptoms have entirely disappeared except for the immobility. It is easy to imagine that this is nature's manner of splinting a badly diseased joint and the process of ankylosing may be a peculiar compensatory reaction to whatever toxic factor is originally responsible for the pathological changes.

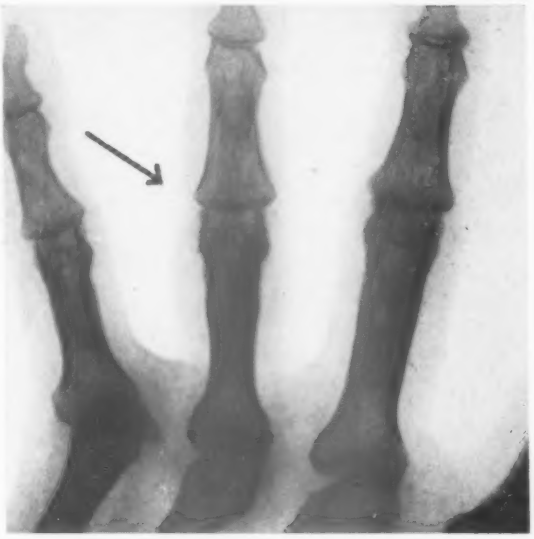

Fig. 12. Case v. Well-marked bony ankylosis of the mid-phalangeal joints, irregularities about the joint borders, generalized atrophy including the shafts. Ulnar deviation at the metacarpophalangeal joints, slight remaining periarticular thickening. Advanced stage atrophic arthritis (see Fig. 6). Most characteristic joint indicated by arrow.

The roentgen appearance shows little or no general soft tissue swelling and the periarticular thickening is not so marked as previously. The joint capsule has now undergone fibrotic changes and the fibrous tissue has contracted, so that in some cases we may see a narrow band of increased density lying in close relation to either side of the former joint area; in other cases an irregular mottled thickening is present, which may contain small calcium or bone deposits. These are the remains of deposit within the plicae, which were previously described as being formed by the infolding of the synovial membrane. In still other cases no suggestion of thickened periarticular tissue can be recognized. In all cases there is marked atrophy of the muscles which cross over the joint region or insert in the neighborhood of it. This is readily seen on the roentgenogram. At about the time the bone ends begin to fuse, or shortly after, it is not uncommon to see one bone end "telescoping" or partially projecting into the broadened end of the opposite bone. This is due to the weakening of the structure by the withdrawal of calcium salts and causes an actual shortening of the longitudinal diameter of the affected bone and a corresponding widening at the base. This is simply secondary to the gradual softening of the structures and is not regarded as being caused by the addition of new bone formation. The zone of provisional calcification partially or completely disappears as time goes on and continuous strands of rather homogeneous trabeculated bone pass directly across the joint area. At this stage especially it is not uncommon to see rather large irregular areas of rarefaction adjacent to the disappearing remains of the zone of provisional calcification. Finally the two bones are completely united by one continuous fusion of cancellous bone and there may even be a differentiation between the cortex and medullary portions in this region similar to that in the main shaft. On sectioning through these bones it is not surprising to find that the actual medullary canal is as well marked at this point as it would be in the mid-portion of the shaft. There is

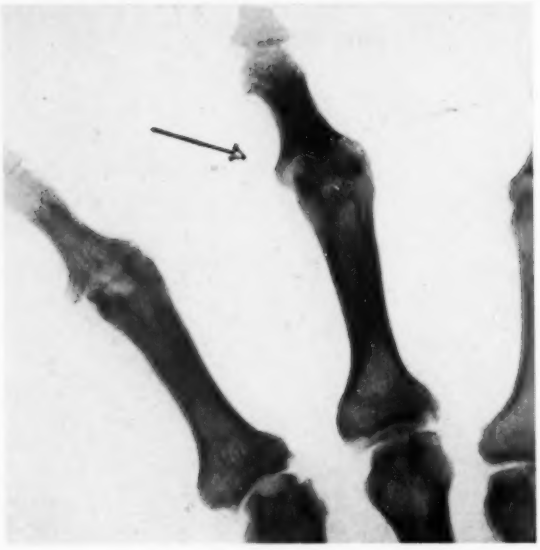

FIG. 13. Case IX. Fusion of the bones with "telescoping" of the heads of the proximal phalanges into the bases of the middle phalanges. Atrophy not so marked in this case but small spotted areas are present. Small punched out areas and spicule formations along joint margin at the bases of the proximal phalanges. This roentgen appearance indicates a stage between Figures 6 and 7. Most characteristic joint indicated by arrow.

universally widespread atrophic change throughout. The final stage may be visualized as completely healed; the bones are not only ankylosed but it is often more difficult to break them through the joint line than through a narrower portion of the shaft. Long before these changes are complete practically all clinical symptoms have subsided and the patient is in comfort except for the immobility of the member affected. The summary of the roentgen appearance of the late stage would be as follows (Figs. 13 and 14):

1. Generalized atrophy throughout all bone structure.
2. Complete or partial disappearance of the zone of provisional calcification and sometimes enlargement of the punched out areas in the immediate vicinity.
3. Deformity of the bone ends due to softening and "telescoping."
4. Continuity of the trabeculated bone which crosses from one bone end to the other.
5. In many cases continuity of the cortex and marrow structures forming a continuous shaft.
6. Little or no remaining periarticular thickening or generalized soft tissue swelling.
7. Atrophy of the muscles generally, which attach about the vicinity of the affected joint.

HYPERTROPHIC ARTHRITIS—EARLY STAGE

The early stage of hypertrophic arthritis (Fig. 15) presents in a general way the following course: There is no proliferation of the synovial membrane with pannus formation. The first evidence of change is a fibrillation of cartilaginous matrix, which begins usually in the central portion where the circulatory supply is poorest. It is not definitely settled whether this change is caused by some chemical component of the synovial fluid or by other factors, but a gradual softening and later erosion of the cartilage results. This does not take place in any uniform pattern but irregular areas are destroyed and the surface of the car-

FIG. 14. Case VI. Solid bony union of the middle phalanges with continuous spongy bone. A few preserved remnants of the zone of provisional calcification. "Telescoping" of the heads of metacarpals into bases of proximal phalanges. Marked local atrophy about the joint structures and rather generalized disuse atrophy of shafts. Advanced stage atrophic arthritis (see Fig. 7). Most characteristic joint indicated by arrow.

tilage becomes deeply pitted until entire areas are removed and the underlying bone is exposed. There is proliferation of the perichondrium of the opposite side of the joint, causing new growths of cartilage which fit into the areas of erosion and give the appearance, when the joint is opened, of knob-like projections causing the line of articulation to become grossly irregular. The joint capsule and surrounding periarticular tissues may be moderately thickened but this is usually not evident unless the joint passes through an acute arthritic stage. This, however, can easily be caused by some slight trauma and in such cases we may find increase in the synovial fluid and the usual appearance of the very early stage, which is common to all forms of arthritis. The synovial membrane usually appears normal although in some cases small papillary masses, either sessile or pedunculated, consisting of connective or granulation tissue may form within the folds. The endosteum of the marrow spaces shows an active proliferation, which causes an increased density of the zone of provisional calcification. There is no penetration through this zone by means of any vascular loops of granulation tissue. About the margins of the joints, new bone formation begins to occur and small spur formations extend into the cartilage and about its periphery. The first growths are usually an ossification of cartilage material and occur about the margins where the blood supply is the best. Goldhaft, Wright and Pemberton, in a very interesting experimental study, have demonstrated that these new bone formations may be caused by interference with the local blood supply. There are few or no atrophic changes at this stage and the bone detail otherwise appears normal.

The first recognizable roentgen indication of hypertrophic arthritis is the formation of small bony spurs at the joint margins. These are often quite sharp and prominent; in most cases they can be shown to consist of osseous material, and a differentiation from a similar type of calcium deposit in the atrophic form can be made. These are formed by bone deposit within the previous overgrowth of cartilage and may easily be the result of local circulatory disturbances. The irregularity of the cartilage cannot be shown by the roentgen ray, and no indication of any pathological change is demonstrated within the joint space until a slight narrowing is observed. This closer approximation of the bony surfaces may be in a regular manner but is often more marked on one side than

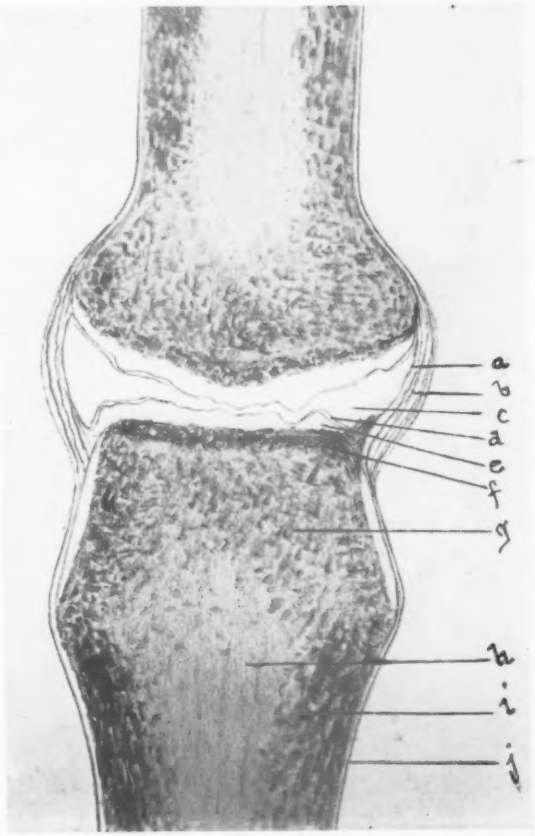

Fig. 15. *Hypertrophic arthritis—early stage.* Diagrammatic illustration of pathological changes in early hypertrophic arthritis. *a*, *b*, *c*—little or no thickening of the synovial membrane and joint capsule, joint space of normal width, *d*—perichondrium destroyed in places and proliferating elsewhere to form new cartilage, *e*—cartilage eroded and dissolved, resulting in gross irregularity of surfaces, *f*—spur formation rising from the zone of provisional calcification and extending into the junction of cartilage, bone and capsule, *g*, *h*, *i*, *j*—unchanged.

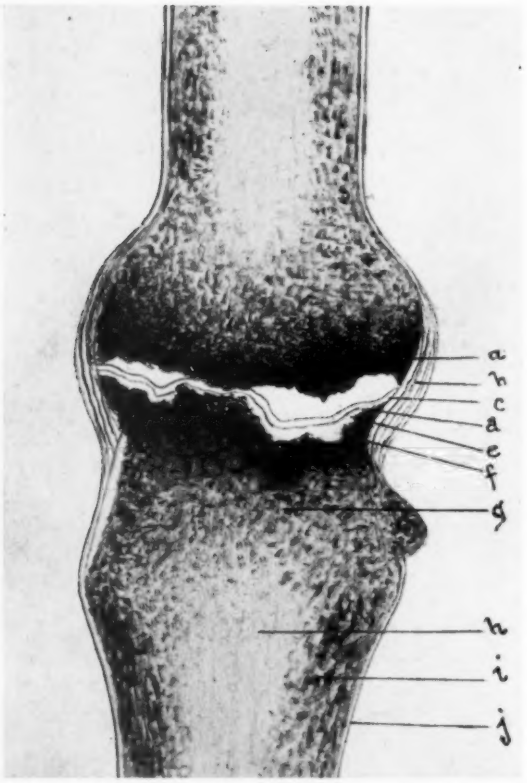

Fig. 16. *Hypertrophic arthritis—intermediate stage.* Diagram of intermediate stage. *a*, *b*—synovial membrane and capsule slightly thickened, *c*—joint space definitely narrowed and irregular, *d*, *e*—perichondrium and cartilage irregularly eroded but partially preserved, *f*—thickening and irregular area of the zone of provisional calcification, *g*, *h*, *i*, *j*—unchanged.

the other, resulting in a narrowing of the joint space on this side as compared with the opposite and a slight tilting or difference in the angulation of the longitudinal axes of the bones. There is an appearance of irregularity in the zone of provisional calcification somewhat similar to that described under the atrophic form, but our impression has been that decidedly more thickening of this zone is usually present, due to the osteoblastic activity of the endometrium in the proximal spongy bone and to the lack of invasion by the capillary loops of granulations. There is certainly less general disturbance of this zone in the hypertrophic variety. The thickening of this band of increased density may be fairly uniform or more marked in places where stress or strain is greatest. The increase in the circumference proximal to the joint space often causes an apparent flattening of the contour of the joint surfaces. When present, this is quite typical and has often led us to suspect an early hypertrophic arthritis when no spur formations could be recognized. A little later the irregularities caused by the erosion of the bony surfaces may be recognized. Sometimes these form definite saw-toothed notches, the prominences of which appear to correspond to the depressions in the opposite surfaces. This is seen before the joint space is obliterated by cartilage absorption. Occasionally, very early in the

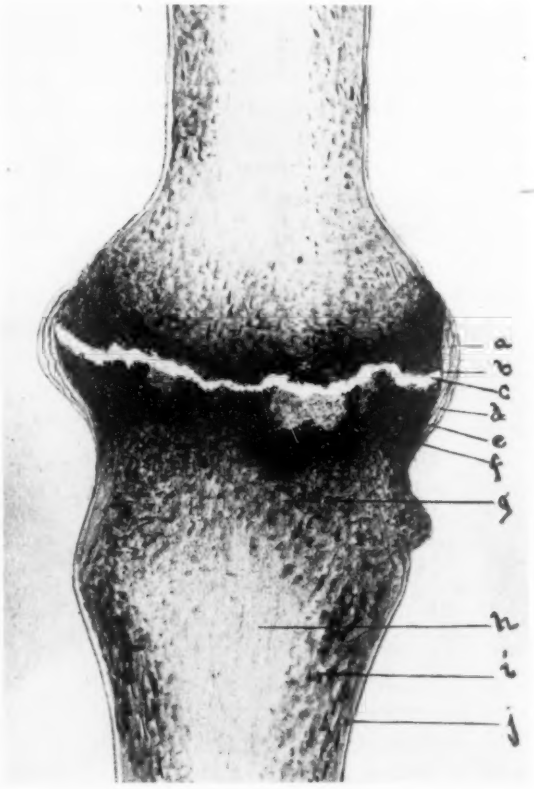

Fig. 17. *Hypertrophic arthritis—intermediate stage.* Diagram of intermediate stage. *a*, *b*, *c*, *d*, *e*—cartilage has disappeared but joint space still preserved, bony ends now articulating, *f*—zone of provisional calcification thickened and punched out areas of decreased density containing mucoid material, *g*, *h*, *i*, *j*—unchanged although slight atrophy may be present.

process subluxations may be recognized. At any time, in this early stage, we may find the associated roentgen evidence of acute inflammation with widening of the joint space, due to increased synovial fluid and thickening of periarticular structures. It is almost the rule to recognize small areas of atrophy due probably to disuse but this atrophy has a different appearance from that seen in the atrophic variety. The trabeculae are well preserved and stand out sharply. In practical work we have often referred to this as the "honeycomb" type of atrophy in differentiating it from the "ground glass" type of the atrophic variety. In summarizing the early stage, we regard the typical roentgen appearance as being the following (Figs. 20 and 21).

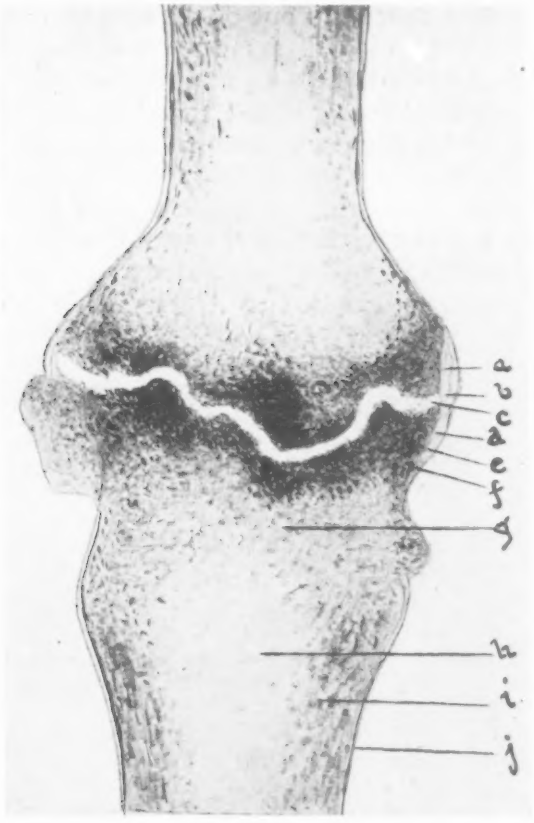

Fig. 18. *Hypertrophic arthritis—advanced stage.* Diagram of advanced stage. *a*, *b*, *c*, *d*, *e*—capsule is thinner than normal, other structures have disappeared, two bony ends articulate and joint space irregular, *f*—thickening of zone of provisional calcification with formation of nodule of new bone growth, *g*, *h*, *i*—atrophy of the secondary or "honeycomb" type, *j*—periosteum unchanged.

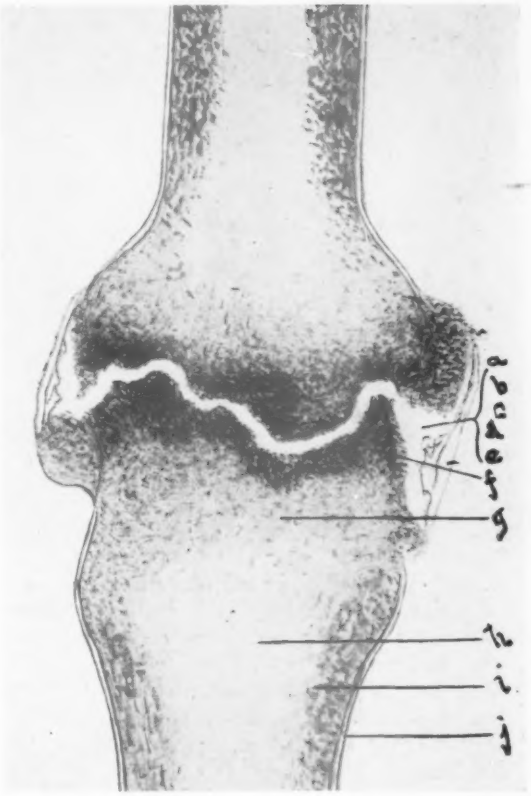

Fig. 19. *Hypertrophic arthritis—advanced stage.* Diagram of advanced stage. *a*, *b*, *c*, *d*, *e*—capsule stretched between bone ends, cartilage eroded away from bone ends, *f*—zone of provisional calcification becomes the area of eburnation; spur formation and broadening of the circumference due to bony nodules but no fusion, *g*, *h*, *i*, *j*—secondary atrophy.

1. Small osteophytes about the joint margins.
2. Narrowing of the joint space.
3. Slight tilting or change in alignment of bones
4. Thickening of the proximal zone of increased density.
5. Irregularities of the bony articular surfaces.
6. Broadening of the circumference, often causing apparent flattening of the joint surfaces.
7. Secondary atrophy of the "honeycomb" type.

HYPERTROPHIC ARTHRITIS—INTERMEDIATE STAGE

As the processes approach the intermediate stage (Figs. 16 and 17) the

Fig. 20. Slight swelling of soft tissues and thickening of periarticular tissues, small sharp spur formations at joint margins. Very early atrophy of the "honeycomb" type. There is very little narrowing of the joint space but a tendency to flattening of joint surfaces. Early stage hypertrophic arthritis (see Fig. 15). Most characteristic joint indicated by arrow.

above changes become progressively more marked. The cartilage shows a tendency to extensive proliferation about its attachment to the capsule. This overgrowth becomes ossified and there results a decided increase in the circumference and diameter of the bone about the neighborhood of the joint surface. These overgrowths may be irregular, forming nodular masses of bone which are the typical Heberden's nodes. In other places large irregular spur formations are present. The bony trabeculae are fairly well preserved. Due to the bony overgrowths and irregularity of the articular surfaces subluxations occur. The progressive erosion of the cartilage finally results in exposure of large surfaces of the underlying bone. This in turn becomes eroded but never ankyloses with the opposite bony surfaces. It first presents a rather granular surface but in time begins to eburnate, probably due to friction, and increases in density gradually until a very highly polished shell of bone forms a new articulation in place of the cartilage. Within the thickened folds of synovial membrane cartilage is deposited, later becoming osseous tissue and breaking off to form joint mice. The synovial cavity in some cases is filled with a mass of débris, mostly broken off pieces of cartilage, which for a long time remain free and finally are absorbed. Within the spongy bone the cells of the endosteum proliferate and deposit new bone about the trabeculations, filling in the marrow spaces and forming a dense layer which replaces the original zone of provisional calcification. This does not extend very far into the bone but is fairly well localized in the vicinity of the joint surfaces. Small cyst-like cavities are formed by the dissolving out of the spongy bone and depositing of a mucoid material. In some cases these are just proximal to the zone of eburnated bone but they may be scattered anywhere throughout the spongy texture.

On roentgen examination we are likely to find obliteration of the joint space with contact of two bony ends but never fusion. We must not be led astray by a roentgeno-

Fig. 21. Case VII. More narrowing of joint spaces. Note subluxation of distal phalanx of the fifth finger and spur formations about the joint margins. Slight increase in atrophy. Roentgen appearance indicates a stage between Figures 15 and 16. Most characteristic joint indicated by arrow.

gram from a certain angle which causes an apparent fusion of the bones, since this appearance may be simulated by overlapping of the bones and distortion of the articular surfaces. If several films are taken at various angles we can often demonstrate the joint space but in many cases we are not satisfied until we have examined the extremity and determined that motion is present. The increased density of the zone of provisional calcification may be very well preserved and in places greatly thickened, or it may show irregular areas of extreme thinness where the bone has been eroded and the process of eburnation is not yet sufficiently advanced to give roentgen evidence. Small punched out areas, due to the above described bone absorption and deposit of mucoid material, may be easily recognized. In the smaller joints these are most likely to occur adjacent to the joint surface. In the larger joints they may be scattered in the spongy bone. The spur formations are now usually very well marked and the definite appearance of bone trabeculae can be plainly recognized. The broadening of the circumference of the two bones, in close relation to the joint, is well marked and appears similar to the mushroom type of overgrowth, which is usually different from the telescoping of the atrophic form. This is caused by growth of new bone and although there is softening and bending of the bone with shortening in many instances, there is usually associated addition of new bone. In places this occurs in irregular nodes, which can be easily recognized on the roentgenograms and also felt as bony prominences. The irregular saw-toothed appearance of the joint space is often well marked at this stage and subluxations are a prominent feature. The atrophy has by this time usually extended far into the shaft or involved its entire length. It may, however, involve some bones considerably more than others, notably those which have been favored by the patient on account of the pain. In summarizing the roentgen appearance at this

Fig. 23. Case II. Considerable periarticular thickening. Marked narrowing of joint spaces with proximity of the two bony surfaces, indicating advanced cartilage destruction. Broadening of the circumferences. Subluxation and small punched out areas proximal to joint surfaces. Intermediate stage hypertrophic arthritis (see Fig. 17). Most characteristic joint indicated by arrow.

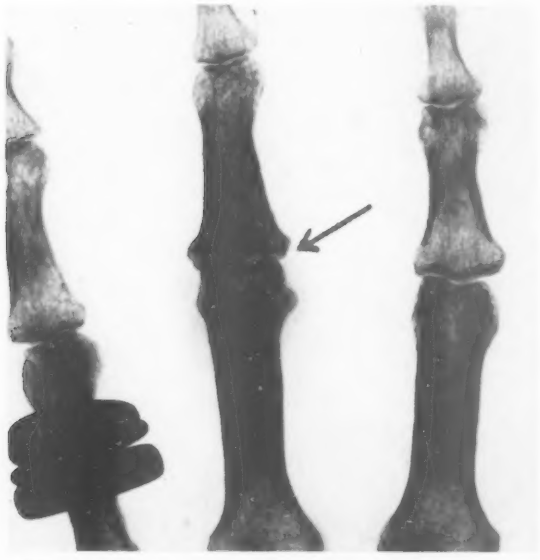

Fig. 22. Case III. Further narrowing of joint spaces. Cupping of articular surfaces with irregular outgrowths of bone proximal to joint margins and notching of articular surfaces, especially middle phalanx. Thickening of periarticular tissues. Intermediate stage hypertrophic arthritis (see Fig. 16). Most characteristic joint indicated by arrow.

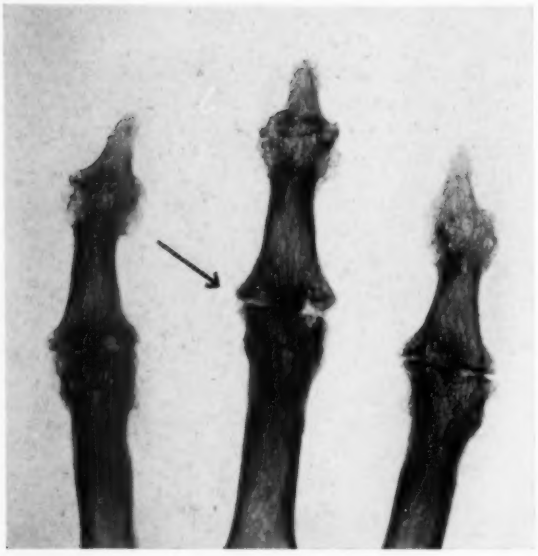

Fig. 24. Case IV. Note the apparent bony ankylosis and obliteration in terminal phalanges. This is due to the distortion of joint space, which was still preserved and large bony outgrowths in the vicinity of the joint (Heberden's nodes). There is "mushrooming" of the terminal portions of the phalanges with widening of the circumferences of the joint surfaces. Irregular punched out areas. Increase of density of bone just proximal to the joint spaces, most marked in the bases of the middle phalanges and rather advanced secondary atrophy throughout. The roentgen appearance indicates a stage between Figures 17 and 18. Most characteristic joint indicated by arrow.

stage we would note the following features (Figs. 22 and 23):

1. Well-formed spurs.
2. Obliteration of the joint space.
3. Subluxations of the bones.
4. Irregular thickening of the zone of provisional calcification in places and thinning in other places.
5. Saw-toothed appearance of the articular surfaces and punched out areas.
6. Broadening of the circumference and formation of Heberden's nodes.
7. Advanced secondary atrophy, often involving nearly the entire shaft.

HYPERTROPHIC ARTHRITIS—LATE STAGE

When the late stage (Figs. 18 and 19) is reached the cartilage is usually completely degenerated and dissolved. There are gross irregularities of the articulating bony surfaces, which appear as deep ridges crossing the bone, and marked tilting and deformity of the articular angles. In a similar manner to that described for the cartilages, we find the bony prominences fitting into the hollowed out surfaces of the opposite bone, resulting in a grossly irregular joint space. The normal motion of the joint is limited and they finally become locked but the bones never fuse and the joint space is never completely obliterated. In some locations, especially the hip, the tendency to erosion may be very slight and the head of the femur may present a smooth polished surface similar to an ivory ball. The greatest degree of eburnation roughly corresponds to the maximum point of weight bearing and friction. The shaft shows a high degree of atrophy and due to the secondary absorption of calcium salts the general structure becomes softened and weakened to such an extent that there may be an actual bending of the bone. There is never true lymphoid infiltration or inflammatory type of exudate which characterizes the atrophic arthritis. The muscles in the late stage show a secondary atrophy, which may become very marked.

Fig. 25. Case X. Note especially a large node formation and increase in density corresponding to the zone of provisional calcification, also subluxations. Advanced stage hypertrophic arthritis (see Fig. 18). Most characteristic joint indicated by arrow.

On roentgen examination there is gross deformity of the articular surfaces with tilting of the facets and secondary subluxations, throwing the longitudinal axes of the bones out of alignment to a very marked degree. Large irregular spur formations and bony overgrowths are recognized and these tend to abruptly limit joint motion. The zone of provisional calcification is now replaced by a dense and sometimes thick area of eburnation, which casts an opaque shadow obliterating the trabecular appearance. This is often a narrow band but in points where there is a sliding motion of one bone on the other, as in the knee or elbow, the roentgen appearance of the entire ends of the bones may be increased in density, as the eburnation involves whatever surface is subjected to friction. The atrophy is very marked in almost all cases and the bones may be decidedly bent or distorted by the weakening of the structure. The cortex is thin and the atrophy of the surrounding soft structures, especially of the muscles, may be recognized. The summary of the roentgen appearance would be as follows (Figs. 24, 25 and 26):

1. Large irregular spur formations.
2. Gross irregularity of the joint space caused by obliteration and deformity secondary to erosion.
3. Marked subluxations with displacement in alignment of the axes.
4. Eburnation of the bone proximal to the joint space.
5. Punched out areas and gross deformity with one bone fitting into the irregularities of the other.
6. Broadening of the circumference to a marked degree.
7. Advanced secondary atrophy with occasionally bending of the bones.

Fig. 26. Extensive subluxations. Note how the overgrowths fit into the notches of the opposite joint surface, especially middle phalanx. There is marked broadening of bases of the phalanges, spurs and bony overgrowths, eburnation proximal to joint margins. A few small punched out areas, rather generalized honeycomb atrophy. Advanced stage hypertrophic arthritis (see Fig. 19). Most characteristic joint indicated by arrow.

Fig. 27. Case 1. Slight atrophy in bone ends, especially in head of radius and olecranon, irregularity of bone structure proximal to the articular surface of joint. Narrowing of joint space. Early stage atrophic arthritis. Most characteristic feature is narrowing of joint space, irregularity of articular surfaces and atrophy of ground glass type.

Fig. 28. Case II. Roughening and irregularities of joint surfaces. Increased density proximal to joint space in femur and tibia. Spurs varying from 2 to 8 mm. about joint margins. Slight generalized atrophy of all bones. Moderately advanced stage hypertrophic arthritis. Secondary atrophy, especially in patella. Most characteristic features are the gross irregularities of the joint surfaces, spur formations and eburnation of articular surfaces of femoral condyles.

CASE REPORTS

The following 10 histories are from those selected to show changes in phalangeal joints and are briefly summarized as a basis for comparison between clinical and roentgen findings. These are from the services of Drs. Pemberton, Peirce, Bockus, Laws and Speese at the Presbyterian Hospital.

Case I. Male, aged thirty-six, married, weight 110 pounds. Admitted to hospital September 23, 1932.

Five years ago patient began to notice numbness and tingling of the fingers, later running up to the elbows, worse during the night or on resting than when moving about. Four years ago he had an attack of severe stabbing pain in the right shoulder. After this disappeared the left became involved and gradually various other joints became painful and stiff. There was no involvement of the spine. He has had relapses with few periods of freedom from acute symptoms, the longest being two months in duration. Seven months ago he was forced to suspend work as a crane operator. He visited many doctors with little relief; colonic irrigations, vaccine, foreign protein injections, physiotherapy and various medicines were given. He has lost 30 lb. in past three years.

Past history contained nothing of value.

Family history revealed no tendency to joint affections.

On examination all joints were involved, some more limited than others. There was swelling which seemed rather to be soft tissue than bony, palms of hands especially were swollen. Physical examination otherwise was normal throughout and search for foci of infection failed to reveal any.

Roentgen examination showed a moderately advanced atrophic arthritis (Figs. 10 and 27). There was ptosis and atonicity of the stomach, redundant colon with sharp angulations but no unusual delay of the motor meal.

Laboratory Findings. Urine, few hyaline and granular casts, otherwise negative. Hb 72 per cent, red blood cells, 4,360,000; white blood

Fig. 29. Case IV. Marked overgrowth of bone about acetabular cavities. Dense deposits of calcium or bone about the vicinity of acetabulum and also head of femur, narrowing of the joint space, general irregularities and spur formations about head, neck and trochanters. Advanced stage hypertrophic arthritis. Most characteristic feature is widespread overgrowth and condensation.

cells, 5,250; blood sugar, 89 mg. Wassermann and Kahn tests negative.

Treatment not as yet outlined.

Case II. Male, aged, fifty-two, married, weight 112 pounds. Admitted to clinic March 15, 1932, in moderately advanced stage hypertrophic arthritis.

Twenty-two years ago following a cold the patient had acute rheumatic fever; he was in bed eleven weeks and although all symptoms cleared up he was left with a stiff right knee. Two years ago he fell and since has had more or less constant pain and swelling. In past few months the other knee and left ankle began to show tendency to stiffness. No previous treatment.

Past history and family history irrelevant.

Examination. Right knee was swollen slightly apparently due to periarticular tissue; there was very slight limitation of motion, but as the knee was bent there was distinct crepitation. All joints showed stiffness but other than a bilateral hallux valgus and deformity of fingers examination revealed nothing of importance. Infected tonsils were removed, one tooth was abscessed and was removed, no other foci discovered.

Fig. 31. Case VI. Cartilage destruction, fusion of bones, irregular deposits of calcium salts, discrete punched out areas of atrophy with generalized advanced atrophic changes throughout all bones. Advanced stage atrophic arthritis. Most characteristic feature is the fusion of the bones and the type of atrophy which is of ground glass variety.

Fig. 30. Case V. Considerable bone destruction and softening with head of femur sinking far into acetabulum. There is, however, some cartilage remaining and no appearance of bony ankylosis. Outline grossly irregular and moderate atrophy in surrounding bones. Moderately advanced stage atrophic arthritis. Most characteristic finding is the softening of bone and absorption allowing the head of the femur to project into the acetabulum.

Roentgen examination showed advanced hypertrophic changes (Figs. 23 and 28). Gastrointestional tract normal throughout.

Laboratory Findings. Urine negative. Hb 86 per cent, red blood cells 4,500,000; white blood cells 8,100; blood urea nitrogen, 14.5 mg. Wassermann and Kahn tests negative.

Treatment has been physiotherapy, massage, ultraviolet, etc., diet and rest. Patient is relieved of considerable soreness, otherwise unchanged. Still reports to clinic.

Case III. Female, aged fifty-five, married, weight 106 pounds. Admitted to hospital April 2, 1930.

Eight years previously began to notice stiffness and pain involving practically all of the joints and muscles, at some time more severe in certain groups. The onset was very gradual and

the symptoms would move about, first in the arms, then shoulders and neck, then hips and legs. In the course of time all the joints became more or less involved. There were definite periods of exacerbations and remission of symptoms but at no time in the course of illness has there been complete relief. Very seldom has the soreness been associated with any sharp pains. During the period of exacerbations the affected joints would become swollen and the resulting

FIG. 32. Case VII. No narrowing of joint space, small irregular spur formations about margins of bones, no atrophy. Early stage hypertrophic arthritis. Most characteristic feature is the spur formation. This degree of change is often seen in patients with no associated clinical symptoms, and is then regarded as a "potential" condition.

stiffness would be noticed during the intervals of remission. The course has been progressively advancing to the date of admission. Medical advice was sought on several occasions with apparently no relief.

The past history was irrelevant except for chronic constipation as far back as the patient can remember. Curettage at thirty-three years of age for benign hemorrhage and tonsils removed at the age of forty-one without relief of arthritic symptoms.

The family history indicated no tendency to joint conditions or serious organic disease.

On examination the patient appeared nervous and depressed. The joints were involved; the greatest degree of ankylosis was in the fingers, wrists, elbows and knees. The joints were ankylosed in a flexed position and swelling was present, which was partially bony but to some degree due to soft tissue. There was rather marked atrophy of the muscles throughout.

The teeth were negative to both roentgen and dental examination and no foci of infection could be found.

Roentgen examination revealed moderately advanced hypertrophic changes in all joints (Fig. 22). Gallbladder was dilated, ptosed and functioned sluggishly. Gastrointestional studies negative except for a very long, angulated, atonic colon with marked regurgitation into the terminal ileum.

Laboratory Findings. Hb 100 per cent; red blood cells 5,330,000; white blood cells 6,250; differential count normal. Blood urea nitrogen, 11.9 mg. Wassermann reaction negative.

Treatment consisted of rest in bed, dietary regulations, massage, ultraviolet and medication.

Patient was discharged June 24, 1930, decidedly improved as to the discomfort and soreness in the joints and referred to her family physician for future treatment.

CASE IV. Female, aged sixty, married, weight 224 pounds. Admitted to dispensary February 8, 1932.

Eighteen years ago began having severe attacks of pain in lower lumbar, sacroiliac region and hips. No apparent cause. Very gradually stiffness began to develop in all the joints, first affecting the knees and fingers, unassociated with pain except after some slight injury, at which time the affected joint would swell considerably and gradually recede. During this time there has been dyspnea and palpitation with headaches and insomnia. The pain in the back and hips has not been as severe during the past two years but the general course has been gradually progressive.

The past history revealed an artificial menopause at the age of forty-seven secondary to radium treatment for uterine fibroid, which reduced the tumor mass and stopped hemorrhage but did not influence the back pain. The

patient has been through several attacks of influenza and had tonsils removed five years ago but sore throats continued.

The family history was irrelevant.

On examination there was no definite enlargement of the joints and no muscle atrophy but various degrees of limitation of motion and small hard nodular swellings, especially about the fingers.

The teeth had been extracted. Tonsils showed regrowth and were definitely infected. Pelvic examination was negative. There was slight cardiac enlargement. Blood pressure 154/90. Evidence of myocardial degeneration but no edema.

Roentgen examination revealed advanced hypertrophic arthritis of all joints (Figs. 24 and 29). Sinuses showed no pathology. Heart measurements were a trifle enlarged. Gastrointestinal studies were not done.

Laboratory Findings. Urine negative. Hb 89 per cent; red blood cells 4,760,000; white blood cells 6,400. Blood urea nitrogen 12.4 mg. Wassermann and Kahn tests negative.

Treatment consisted of roentgen irradiation of tonsillar areas as further operation was not deemed advisable, orthopedic shoes, diathermy, massage, regulation of diet and rest advised. The patient has shown gradual improvement and still reports to the dispensary.

Case v. Female, aged fourteen, single, weight 90 pounds. Admitted to hospital February 4, 1929.

Four years previously had sudden pain, swelling and redness of the joints involving both hands and wrists, associated with rise of temperature and acute symptoms suggesting rheumatic fever. In a few weeks the condition had left the upper extremities and the feet and ankles became involved. The symptoms never entirely cleared up but very gradually spread to the elbows, knees and hips. Difficulty in walking was first noticed three years ago and four months before admission the patient became bedfast with severe pain in the right hip, which has been continuous since that time. Patient has been constantly under a doctor's care and at intervals vaccine and Coley's fluid were administered. The Coley's fluid caused a moderate reaction after each injection.

The past history was negative, patient being in good health until date of onset.

Family history was irrelevant.

On admission the patient was in acute distress, the pain being especially severe in the right hip. There was gross deformity of most joints, stiffness of both hips and complete loss of power of hands and feet. Thorough examination was made for foci of infection but none was discovered. The temperature ranged between 99° and 102°F., with daily exacerbations.

Roentgen examination revealed advanced atrophic arthritis of the hands and hip joints (Figs. 12 and 30). Other roentgen studies were not made.

Fig. 33. Case x. Extensive broadening of the articular surfaces with large irregular spur formations and regrowth of bone, narrowing of joint space with marked increased density in the vicinity of the articular surfaces, appearing to extend for a considerable distance into the trabeculated bone. Secondary atrophy of the patella and to a slight degree in the femur and tibia. Advanced stage hypertrophic arthritis. Most characteristic feature is the overgrowth and eburnation. Many cases of the "potential" variety do not show outstanding symptoms until this stage is reached.

Laboratory Findings. Urine was negative, no other laboratory work done during stay at hospital.

Patient left the hospital February 6, 1929, unimproved with recommendation to the family physician for future treatment.

Case vi. Female, aged forty-eight, single, weight 89 pounds. Admitted to hospital April 5, 1928.

Onset twenty-four years ago, very gradual, first began in hands, later spreading to all joints of the body, extremities most affected, the fewest symptoms being in spine and hips. No history of exacerbations and remissions but gradual steady downhill course to present date. Previous medical treatment included fifty vaccine injections with no relief of symptoms.

Examination showed bony ankylosis in flexed positions, the knees and elbows flexed to about 45°. Patient emaciated, visceroptotic. Blood pressure 108/76. Other than a yellow vaginal discharge, which has been present for several years, no focal infection was found. Physical examination revealed nothing of outstanding interest.

Roentgen examination revealed very advanced changes in all joints, atrophic type with ankylosis (Figs. 14 and 31). Gallbladder was nonfunctioning. Sinuses free of infection. Chest clear throughout.

Laboratory Findings. Vaginal smears negative for gonococci. Urine negative except for occasional hyaline casts. Hb 67 per cent; red blood cells 3,450,000; white blood cells 5,450; differential count normal. Blood urea nitrogen, 14 mg. Wassermann test negative.

Treatment consisted of supportive measures, diet, rest and physiotherapy. Patient was discharged to continue treatment at home on May 20, 1928, weighing 114½ lb. and generally improved.

Case vii. Female, aged forty-eight, married, weight 128 pounds. Admitted to hospital February 8, 1932.

Main points of history, gastrointestinal upsets of six years' duration, coming in attacks every five to six weeks, resulting in severe epigastric pain. Occasional vomiting. There was a free interval of eleven months during 1930, attacks were then resumed after dietary indiscretions. Diagnosis was made of chronic cholecystitis and weekly gallbladder drainages were carried out over a period of three months with no marked relief. About latter part of 1930 patient began to notice slight stiffness of the fingers and later of the knees and ankles. There was no swelling nor pain. She claims that she has noticed definite increase of stiffness during gastrointestinal upsets.

The past history reveals long periods of nervous and emotional instability with insomnia. Tonsils were removed six years previously. Three pregnancies, children alive and well.

Family history revealed no joint condition. The physical examination was essentially negative throughout except for moderate epigastric tenderness. There was no restriction or swelling noticed in any joints, nor pain to forced extension or flexion.

Roentgen examination revealed very early hypertrophic changes (Figs. 21 and 32); also a non-functioning gallbladder.

Laboratory Findings. Gastric acidity varied from 40/84 at 15 min. period to 60/108 at 90 min. Urine negative. Hb 85 per cent; red blood cells 4,590,000; white blood cells 5,100. Blood urea nitrogen, 11 mg. Blood sugar, 91 mg. Wassermann and Kahn tests negative.

Patient was discharged February 11, 1932, with suggestions to family physician for treatment.

Case viii. Male, aged thirty-eight, single, weight 142 pounds. Admitted to hospital April 21, 1930.

Five months previously patient noticed sudden swelling of ankles, knees and hands. This was associated with tenderness. The following day involved regions became warm and red in color and left hip was involved. Three days later the right hip showed similar symptoms. In a few weeks the acute symptoms subsided but soreness and muscular pains persisted and slight stiffness with limitation of motion in the joints began to be noticed. One month later seven teeth were removed without apparent effect.

Past history revealed tonsils removed thirty years ago. Patient was under suspicion of tuberculosis at nineteen years of age but no recent evidence could be found. He had had bilious attacks over many years.

Family history revealed no arthritic tendencies.

Examination showed moderate degree of swelling about all affected joints, slight stiffness and questionable limitation of motion. There was an irregular fever, rising each afternoon to 99.8°F., which returned to normal after three weeks' treatment.

The roentgen examination revealed early atrophic changes in all joints (Fig. 9). There was delayed function of the gallbladder but no calculi. Gastrointestinal studies showed hypo-

motility of the motor meal, irritability and spasticity of the colon.

Laboratory Reports. Catheterized specimens of urine with smears and cultures were negative. Stool culture *B. coli.* Hb 74 per cent; red blood cells 3,870,000; white blood cells 7,400. Blood urea nitrogen, 15.4 mg. Blood sugar, 90 mg. Wassermann and Kahn tests negative.

Treatment consisted of rest, regulation of diet, physiotherapy, regulation of bowel function and medication. Patient was discharged on November 22, 1930, greatly improved and all acute symptoms quiescent.

Case IX. Female, aged twenty-three, single, weight 105 pounds. Admitted to hospital February 10, 1928.

Eleven years ago patient began to notice pain and stiffness of both wrists. There has never been redness or swelling. The symptoms continued without remission and three months later elbows and shoulders became affected and gradually all joints of the body, with resulting deformities in a flexed position and partial and complete ankylosis, so that the patient cannot walk and gets about in a wheel chair. There has been a striking lack of exacerbations and remissions, the symptoms gradually progressing until the present date.

Past history reveals scarlet fever at five years of age, extraction of numerous decayed teeth and treatment by vaccine.

Family history revealed a tendency to arthritic condition, rather vague and indefinite, the patient stating that her parents and grandparents were troubled with "stiff joints."

On examination there was marked swelling of most of the joints, which appeared to be due to both bone and soft tissue enlargement. The left hip was firmly ankylosed and feet were rigid. The joints of the hands and wrists showed marked limitation of motion. There was moderate limitation of all joints. There was some slight tenderness in the upper right quadrant. Gallbladder drainage revealed poor function. There was questionable splenic enlargement. Otherwise physical examination was entirely normal. No definite foci of infection were discovered.

Roentgen examination revealed advanced atrophic arthritis (Fig. 13); delayed but relatively normal functioning gallbladder; moderate ptosis of the stomach and colon with incompetent ileocecal valve.

Laboratory Findings. Hb 71 per cent; red blood cells 3,710,000; white blood cells 6,950. Blood urea nitrogen, 17 mg. Blood sugar, 92 mg. Wassermann reaction negative. Gallbladder drainage sterile. Stool culture shows non-hemolytic streptococci. Blood culture sterile.

Treatment consisted of vaccine, foreign protein injection, hypodermic iron, regulation of bowels and diet and rest. Patient was discharged from hospital on March 30, 1928, to continue treatment at home.

Case X. Male, aged seventy-five, married, weight 110 pounds. Admitted to hospital on May 21, 1928.

Onset fifteen years ago, very gradual, complaining at first of pains in legs during night after working in his garden. Hands and knees became involved about one year later. Stiffness and limitation of motion began to be noticed after the acute pain subsided. Symptoms spread to all joints except spine. He has tried various climatic changes, baths and massage without relief.

Past history reveals nothing of importance. He had been very strong and healthy, never ill until the onset of present symptoms.

Family history showed no tendency to arthritic condition.

Examination revealed a very well preserved adult, who walks slowly with a slight drag of the right foot. There is stiffness of all joints, moderate degree of swelling present and slight tenderness. The skin is generally dry and atrophic, the muscles of the legs and thigh especially shrunken. Physical examination otherwise entirely negative except pyorrhea and retraction of gums about a few remaining teeth.

Roentgen examination revealed very advanced hypertrophic arthritis (Figs. 25 and 33). Gastrointestinal series was not done. Gallbladder showed normal function, no calculi.

Laboratory Findings. Urinalysis negative; Hb 85 per cent; red blood cells 4,300,000; white blood cells 7,100; differential count normal.

Treatment consisted of massage, colonic irrigations, regulation of diet, supportive medications and removal of remaining teeth. Patient was discharged on June 25, 1928, all pain and soreness relieved, walking greatly improved and feeling stronger and better generally.

COMMENT

It cannot be too strongly emphasized that the above findings are selected from a

general review of large numbers of cases and that they do not represent any typical course of the disease process, in either the atrophic or hypertrophic form, but have been separated in this manner as a basis for understanding the individual features from the roentgenologist's point of view. In a similar manner, the diagrammatic sketches represent only the generally recognized cardinal ideas under consideration, and were outlined only as a means of clarifying our mental pictures when thinking in terms of roentgen interpretation. Out of the above simple outline thousands of highly complicated appearances can be built. One type of case often brought to our attention appears to be unquestionably in the advanced hypertrophic stage but the joint space would seem to be well preserved. On close inspection, it may be demonstrated that the overgrowths about the bony joint margins form false articulating surfaces and the bone ends are held apart, giving the appearance of normal width. This is a single example of the manner in which one phase of the process may overshadow the others to such an extent that we might easily be led to believe we were dealing with different disease processes rather than different manifestations of the same process.

We are convinced that in many cases there is a grafting of one form on the other, in which, as an example, fusion of the bones with ankylosis is found to be associated unquestionably with well-developed spur formations in which bony trabeculae are plainly visible. It is to be supposed, therefore, from the roentgen evidence, that one type of chronic arthritis has progressed up to a certain point and the other type has been grafted on it or that both processes have developed simultaneously. It is not within the scope of roentgenology to attempt to settle this particular problem but in interpreting the roentgenogram it must be borne in mind; in other cases we find the predominance of hypertrophic manifestations in certain joints and unmistakable signs of atrophic in others in the same patient. The roentgenologist must therefore not only be thoroughly familiar with all possible phases of the pathology but must know the roentgen evidence of these various processes and be able to interpret them with a clear understanding of the clinical aspects of each individual case.

SUMMARY

1. An attempt has been made to correlate the roentgen findings in chronic arthritis with the known pathological data.

2. The groups studied are the chronic arthritides of uncertain origin which correspond to the atrophic and hypertrophic classes of the American Committee for the Control of Rheumatism or the proliferative and degenerative groups described by Nichols and Richardson.

3. One thousand cases were collected to approximate, as far as possible, an even distribution of material.

4. The disease processes are roughly grouped, from the roentgen standpoint, into early, intermediate and advanced stages as an aid to interpretation.

5. Emphasis is laid on the necessity for correlation of clinical history, physical findings and roentgenographic analysis in attempting to interpret the roentgen evidence.

6. The roentgen appearance of each stage has been described and compared with its corresponding pathology.

I wish to express my appreciation of the interest and cooperation given by Drs. Pemberton and Peirce and their many valuable comments and criticisms, and also to thank Mr. Case of the Wills Hospital, Philadelphia, for the diagrammatic drawings.

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VISUALIZATION OF THE CEREBRAL VESSELS BY DIRECT INTRACAROTID INJECTION OF THORIUM DIOXIDE (THOROTRAST)*

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DEFINITE advance in the diagnosis of neurological conditions has been made since the introduction by Dandy of ventriculography and encephalography. The technique of roentgenographic visualization of the cerebral vessels by injection of radiopaque substances into the carotid artery has, however, been only sporadically adopted in the United States. This is, in great part, due to the surgical aspects of the procedure. The purpose of this paper is to describe a relatively simple technique which we believe overcomes this objection.

Egas Moniz and his associates,[3,5] Löhr and Jacobi,[9] Jessen and Licht,[8] Trias,[15] and others, have obtained excellent arteriograms and phlebograms of the brain by injecting colloidal thorium dioxide (thorotrast)† into the carotid artery. By means of this method diagnosis of cerebral aneurysm, brain tumor, and other abnormalities in the brain may be made.

The technique of cerebral vasography as practised by the above authors consists in exposing the common or internal carotid artery, ligating the vessel, and rapidly injecting the thorotrast. Egas Moniz[3,5] injects 10–12 c.c. of the medium for arteriography followed by an additional 16 c.c. for visualization of the cerebral veins. He also recommends a single injection of 18 c.c. when the veins, as well as the arteries, are to be visualized. The arteriogram is taken immediately upon completion of the injection of the 10–12 c.c. and the phlebogram about four seconds after the first roentgenographic exposure. At this time the dural sinuses may be visualized.

† We are indebted to the Heyden Chemical Company of New York City for generous supplies of thorotrast.

Löhr and Jacobi[10] have obtained good arteriograms by injecting into the exposed internal carotid artery as small an amount as 4–6 c.c. of thorotrast. For good results with this amount the medium must be injected very rapidly and the roentgenogram taken while the injection is being made.

Because exposure and ligation of the carotid artery constitutes a formidable surgical technique which might cause clinicians to hesitate to utilize the procedure, we have developed a method by which thorotrast may be injected directly into the artery. Direct puncture of the carotid artery in this manner is not difficult.[2,7,11] We have performed several hundred punctures of this vessel in the past seven years with little more difficulty than in entering the brachial artery. In injecting substances, such as thorotrast, complete assurance that the needle is well within the lumen of the vessel is necessary. This requisite may be accomplished by following the technique to be described.

TECHNIQUE OF DIRECT INTRACAROTID INJECTION OF THOROTRAST

The best position for puncture of the carotid artery is the supine, with head hyperextended. In this position the muscles and tissues of the neck are firmly fixed, so that the artery may be entered with the least difficulty. The side of the neck is sterilized and the skin and subcutaneous tissues at the level of the cricoid cartilage are infiltrated with novocaine. In disturbed or uncooperative patients, preliminary sedation or anesthesia with sodium amytal is recommended. Since the common carotid artery bifurcates at the upper border of

* From the Division of Psychiatric Research, Boston State Hospital, Mattapan, Mass., aided by grants from the Commonwealth of Massachusetts and the Rockefeller Foundation.

the thyroid cartilage, where it is practically impossible to distinguish by palpation between the internal and the external carotid arteries, it is well to make the puncture so that the needle enters the vessel well below this point, at the level of the cricoid cartilage. Otherwise, the needle may enter the external carotid and the thorotrast will fail to visualize the cerebral vessels.

Using the fingers placed as a guide over the line of maximum impact of the artery, the common carotid is punctured by a $1\frac{1}{2}''$, No 18–19 gauge needle, connected by means of a three-way stopcock to a 20 c.c. syringe. The stopcock is in turn connected to a glass tube and stiff rubber tubing, both of which are filled with citrate, and finally to an aneroid Tycos manometer.[2] In puncturing the artery the direction of the needle should be as nearly parallel to the skin as possible. Once the blood enters the syringe, the barrel of which is forced up by the pressure of the blood, the stopcock is turned so that the carotid pressure becomes registered on the manometer. If the needle is well within the lumen of the artery, there are observed free and wide oscillations of the manometric needle; and furthermore, compression of the carotid below the site of puncture causes a steady fall in pressure and an immediate return to normal pressure and wide oscillations following the release of the compression. If, and only if, these two conditions obtain, is the syringe disconnected and replaced by one containing the thorotrast. Sufficient concentration of the thorotrast within the cerebral vessels for good roentgenographic visualization may be accomplished by the following two methods: (1) an assistant, standing opposite the operator, may compress the homolateral carotid at the root of the neck, preventing by this means the injected thorotrast from flowing through the cerebral vessels at too rapid a rate; or (2) he may slow down the outflow of blood from the cranial cavity by strongly compressing both internal jugulars over the sternomastoid muscles. While either method of compression is being continued, the thorotrast is injected as rapidly as possible. If the needle is well within the lumen of the

Fig. 1. J. G. Dementia praecox. Cerebral arteriogram. The bifurcation of the common carotid artery and branches of the external carotid artery are also outlined. Injection of 10 c.c. thorotrast into the common carotid artery.

Fig. 2. W. S. Dementia praecox. Cerebral arteriogram. The thorotrast (10 c.c.) was injected into the internal carotid artery. Note the needle in that vessel.

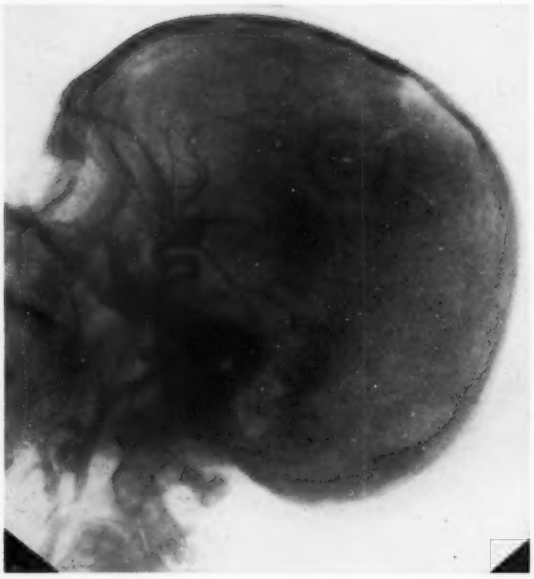

FIG. 3. A. H. Cerebral arteriogram of an arteriosclerotic patient. Cerebral vessels incompletely visualized. Note the marked tortuosity of the first part of the internal carotid artery; 10 c.c. of thorotrast injected into the common carotid artery.

artery, little resistance to the injection is encountered. The method of slowing down the cerebral blood flow by jugular compression appears to be superior to that of carotid compression, first, because there is much less discomfort to the patient and, second, not only are as good arteriograms obtained, but the results thus far indicate that better phlebograms are obtained.

Carotid compression has three disadvantages: (1) it is apt by traction on the trachea to make the patient cough and as a result cause him to move his head while the roentgenogram is being taken; (2) it may displace the needle and thus cause an unsuccessful injection, and (3) it may produce an undesirable degree of cerebral anemia.

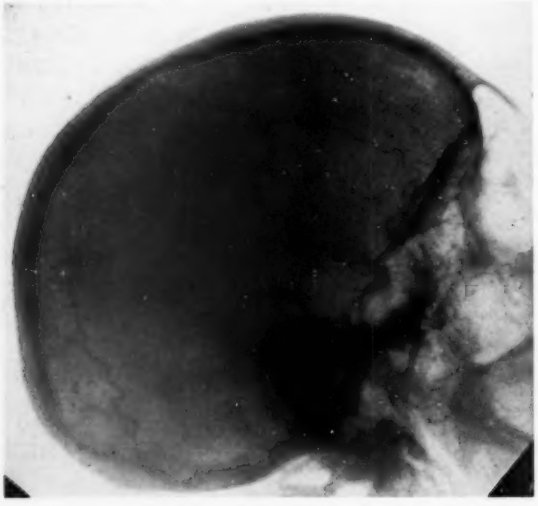

FIG. 4. G. T. Dementia praecox. Visualization of the meningeal arteries and the occipital artery. The thorotrast (10 c.c.) was injected into the external carotid artery.

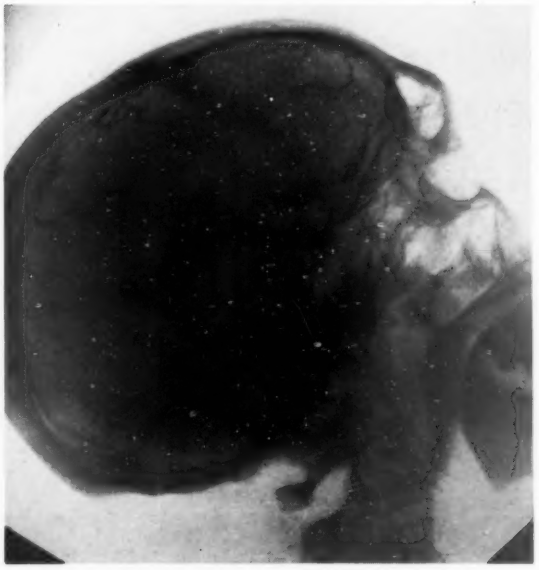

FIG. 5. W. S. Senile patient. Cerebral phlebogram. Visualization of some of the cortical veins; 10 c.c. thorotrast was injected into the common carotid artery. Film taken six seconds from beginning of the injection.

The roentgenographic technique used was as follows: tube distance 60 inches; 80 kv. (peak); 50 ma.; exposure $\frac{1}{2}$ second. Lateral views of the skull were taken. Excellent arteriograms were consistently obtained by making the first roentgenographic exposure immediately at the completion of the injection of 10 c.c. of thorotrast. In one instance, 5 c.c. of thorotrast outlined the cerebral arteries, although with not as great a contrast as with 10 c.c. A fair phlebogram may be made three to four seconds after the first film is taken.

In a few cases, 20 c.c. of thorotrast was injected and the following technique employed: the entire amount was injected as rapidly as possible; a first film for arteriogram was taken when 10 c.c. had been injected; a second film two to three seconds later; and a final film eight to nine seconds from the beginning of the injection. The second roentgenogram usually shows a variable number of veins outlined, and the third roentgenogram may outline the longitudinal sinus, the straight sinus, the lateral sinus, and their tributaries (Figs. 1–8).

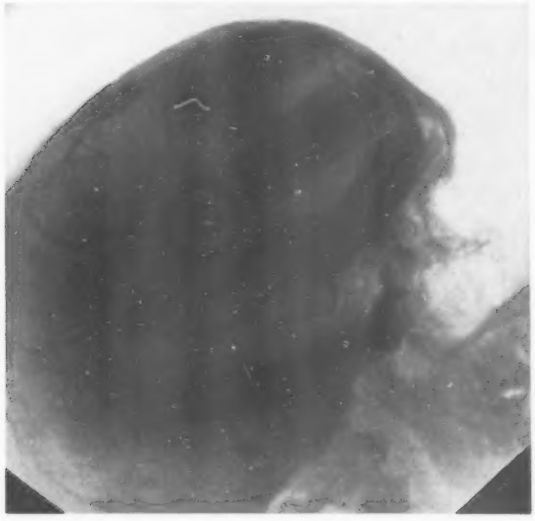

Fig. 6. J. McG. Dementia praecox. Cerebral phlebogram. Visualization of cortical veins; 20 c.c. thorotrast injected into the common carotid artery. Film taken five seconds from the beginning of the injection. The black bands represent two fingers of the assistant who was holding the patient's head. Note also needle (foreign body) in the skull.

COMMENT

In our early cases, before the technique of injection was perfected, thorotrast was inadvertently injected into the tissues around the artery. In these instances (4 cases), no visible inflammatory reaction about the site of injection occurred. Repeated roentgenograms of the neck showed a very slow and complete disappearance of the thorotrast in from three to four weeks. In a total of 30 cases, which have been injected with thorotrast in amounts varying

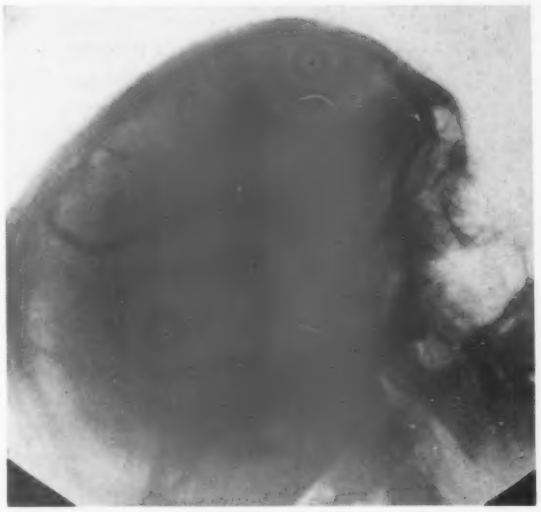

Fig. 7. J. M. Dementia praecox. Cerebral phlebogram. Same patient as in Figure 6. Film taken three seconds later. Note visualization of superior longitudinal sinus and large cortical veins.

from 5–20 c.c., no immediate or late untoward effects have been noted over a period of five months.

Egas Moniz and Pacheco,[4] who have performed more than 300 injections of

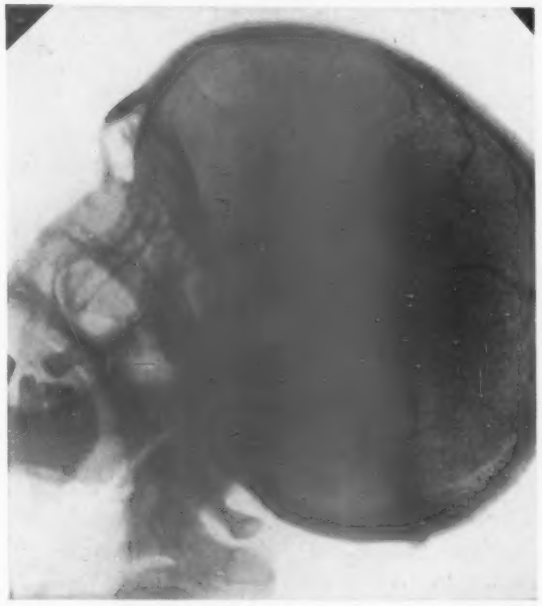

Fig. 8. J. M. Dementia praecox. Cerebral phlebogram; 20 c.c. thorotrast injected into the common carotid artery. Visualization of large cerebral veins. Film taken six seconds from beginning of injection.

thorotrast, report only one case in which undesirable effects occurred. This was in a patient who had a large temporal lobe tumor. Injection of 18 c.c. of thorotrast in this instance resulted in an increase of an existing hemiparesis. Löhr and Jacobi's experience also corresponds with that of Egas Moniz and his associates.

The Council of Pharmacy and Chemistry of the American Medical Association[12] advise against the use of thorium dioxide because of its imperfect elimination from the body, its fairly high alpha-ray activity, and the possibility of its later radioactivity by the conversion of thorium dioxide into mesothorium and radiothorium, which may possibly render the tissues sensitive to roentgen rays. It should be noted, however, that this decision referred to the use of the larger doses (50–75 c.c.) employed for visualization of the liver and spleen.

Yater and Otell[16] state that tests performed by Kadrnka and for them by the National Bureau of Standards of Washington, D.C., showed that the radioactivity of thorium dioxide is negligible. Other possible disturbances of thorotrast, namely, that the substance affects the function of cellular immunity by its action on the reticulo-endothelial system (Hanke),[6] and that it lowers the thrombocytopenic content of the blood (Shih and Jung),[14] also refer to large doses. There appears to be no evidence that such disturbances exist when small amounts of thorium dioxide are used.

Because of the question that thorium dioxide, when injected into the carotid artery of patients who have intracranial vascular lesions, might enter the brain itself and cause damage, Alexander, Jung, and Lyman[1] injected the medium into the brain of dogs and investigated its fate. These authors found that it acted as a foreign substance; that no definite evidence of a special physico-chemical destructive action on axis cylinders or on myelin sheaths could be demonstrated in examinations covering a period of two months following the injection. Colloidal thorium dioxide was transported from the parenchyma of the brain to adjacent blood vessels at a rather quick rate and is thus carried away.

According to Robins and Goldberg,[13] in a group of 30 patients who had been injected with thorotrast (75 c.c.) for visualization of the spleen and liver and who were followed for from six weeks to four years, no apparent effects of the presence of the substance in the body have been noted.

SUMMARY

A technique for obtaining intracranial arteriograms and phlebograms by direct puncture of the carotid artery is described. This technique can be readily mastered and obviates the need of exposing and ligating the vessel. Excellent arteriograms and phlebograms were obtained in 30 patients who received thorotrast in amounts varying from 5–20 c.c. No immediate reactions or late untoward effects of the injections have been noted.

It is probable that in selected cases the technique of direct intra-arterial injections of thorotrast, as outlined above, will be of definite aid in the diagnosis of certain cerebral conditions, particularly in neoplasms and abnormalities of the cerebral vascular tree.

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THORIUM HYDROXIDE SOLS AS OPAQUE MEDIA IN ROENTGENOGRAPHY

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GUTHMANN and Stähler[1] demonstrated the relief of the uterine mucous membrane with thorium dioxide sols. These sols coagulated on the surface of the endometrium to form an opaque coating. They obtained satisfactory roentgenograms with sols having pH values of 3.0 and 5.0 but felt that a less acid medium was desirable. Thorium hydroxide sols were developed to meet this requirement.[2]

CHEMICAL AND PHYSICAL PROPERTIES

Thorium hydroxide is highly insoluble in water and a suspension of it is neutral in reaction. When precipitated from dilute solution, it gives a voluminous white precipitate. In more concentrated solutions, it gelatinizes. The addition of small amounts of thorium nitrate or chloride peptizes this gel and the suspensions can be made much more concentrated without losing their fluidity and low viscosity.

These colloidal solutions are quite stable, but are coagulated promptly in two ways: (1) by an alkaline medium, (2) by a colloidal solution whose particles have an opposite electrical charge to the thorium particles.

The coagulation by an alkaline medium is due to a precipitation of the thorium nitrate in the sol as the hydroxide. Then, the peptizing power of the nitrate is lost and the thorium hydroxide reverts to its gel form, which is its normal condition at high concentrations.

The coagulation by colloidal solutions of opposite charge is due to the neutralization of the electrical charges on the particles. Since these are no longer charged, they cease to repel each other and clump together to form a gel. The charge on the thorium particles is opposite to that of proteins in an alkaline solution, and accordingly mucin and serum proteins cause a coagulation of the thorium suspensions.

The coagulation is more satisfactory when both of the above factors are effective. For example, the acidity of the stomach prevents the coagulation even in the presence of abundant mucus. Cavities with an alkaline secretion but containing little or no mucus do not give satisfactory shadows.

A high concentration of the hydroxide can be reached by peptizing with thorium nitrate. A concentration of 55 per cent has been attained, with the solution remaining quite fluid. These higher concentrations are highly opaque and coagulate into a stiff jelly. They are suitable only for very narrow fistulae and sinus tracts. An 18 per cent solution has been found most suitable in the uterus, greater strengths giving too dense a shadow. The mucous membrane relief of the colon had been demonstrated with much weaker solutions.

The concentration of the thorium nitrate is important in determining the coagulating and adhesive power of the solution. There is an optimum concentration which yields the most satisfactory results. Above and below this, the coagulated film does not adhere well. A 1 per cent thorium nitrate is most satisfactory for solutions up to and inclusive of 18 per cent of the hydroxide. Above this, the nitrate must be increased to keep the hydroxide in suspension.

The acidity of the solution is directly dependent on the concentration of the thorium nitrate, as the hydroxide is insoluble and consequently neutral in reaction. Solutions of thorium nitrate are acid.

[1] Guthmann, H., and Stähler, F. The roentgen demonstration of the fine structure of the uterine cavity. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1933, *47*, 123–141.

[2] Menees, T. O., and Miller, J. D. Demonstration of the relief of the endometrium with thorium hydroxide sols. *J. Michigan M. Soc.*, 1934, *33*, 598–601.

The usual 1 per cent solution gives a pH value of about 6.0. A much less acid solution can be prepared but at the expense of the coagulating power.

UTERUS

As the uterine secretion contains mucus and is alkaline, it causes a coagulation of the solution on the surface of the endometrium. This coagulation is highly opaque to the roentgen rays and relief of the mucous membrane is obtained, which permits the demonstration of early changes in the interior of the uterus.

The technique differs from that of the iodized oils. The injection is made with the cervical canal widely open. If the cervical canal is narrow, it is dilated to in-

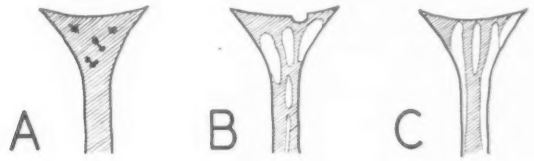

Fig. 1. Diagrams of normal uteri. *A*, postmenstrual mucosa; *B* and *C*, premenstrual mucosa.

sure a free return flow of the solution. This is done to prevent as far as possible the penetration of the solution through the tubes into the peritoneal cavity. The objection to the spilling into the peritoneum is the confusion caused by the additional shadows projected on the uterine relief. It is not always possible to avoid a spilling into the peritoneum, particularly in retrodisplaced uteri. No greater reactions have been encountered than when iodized oil reaches the peritoneal cavity.

The tip of the cannula is carried well up into the fundus and moved back and forth and from side to side. This is to insure a wetting of the entire surface of the endometrium. The injection is made slowly, as this gives a better opportunity for coagulation. Usually about 20 c.c. of the solution is enough, the excess draining back into the vagina.

Films are taken in the anteroposterior, posteroanterior and both oblique direc-

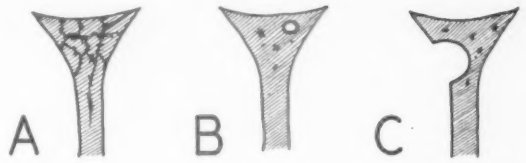

Fig. 2. Diagrams of *A*, hyperplasia; *B*, mucous polyp; *C*, submucous myoma.

tions. The oblique views project the uterine relief in the greater sciatic notch, free from any bony shadows. They also give some information as to the position of the uterus in an anteroposterior direction.

Pelvic inflammatory processes and pregnancy are the only contraindications to the injection of thorium sols. Uterine hemorrhage is not a contraindication as with iodized oils. With proper technique and free return flow, there is no rise in intrauterine pressure to force the opaque material into venous channels as has so frequently happened with the oils. Furthermore the coagulation of the medium with the blood would tend to seal any open vessels.

The normal uterine cavity is triangular on the anteroposterior view and practically linear on the lateral. The cervical canal is usually relatively wide due to the dilatation. The contours are smooth and sharply defined. Occasionally a semicircular in-

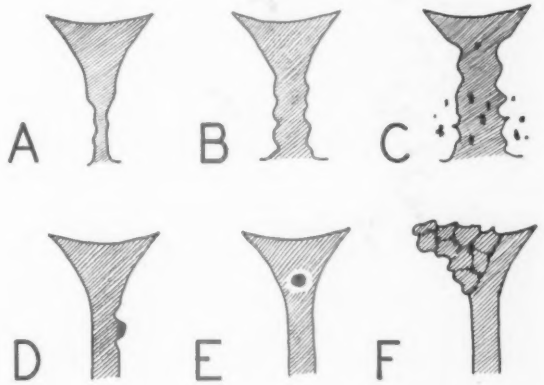

Fig. 3. Diagrams of *A*, early carcinoma of the cervix; *B*, moderately advanced cervical carcinoma; *C*, extensive and deeply eroding cervical carcinoma; *D*, carcinomatous ulcer crater in profile; *E*, carcinomatous ulcer crater on anterior or posterior wall; *F*, corpus carcinoma.

FIG. 4. Hysterogram of corpus carcinoma.

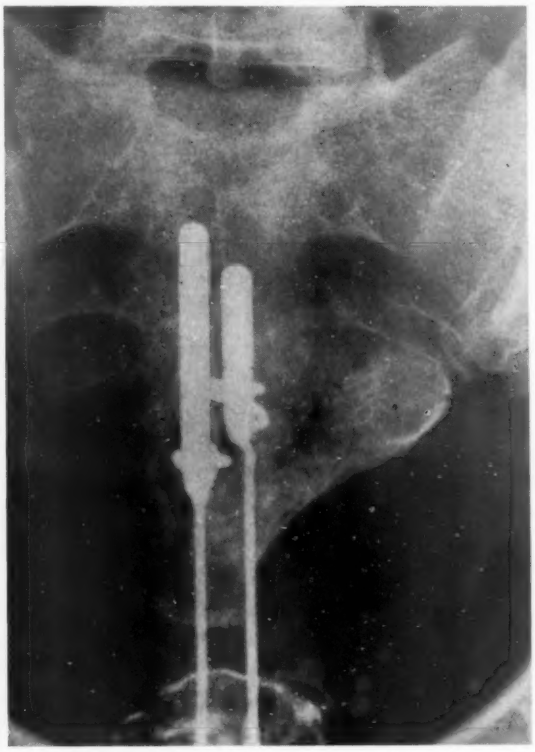

FIG. 5. Hysterogram of same patient as Figure 4. Unsatisfactory radium application.

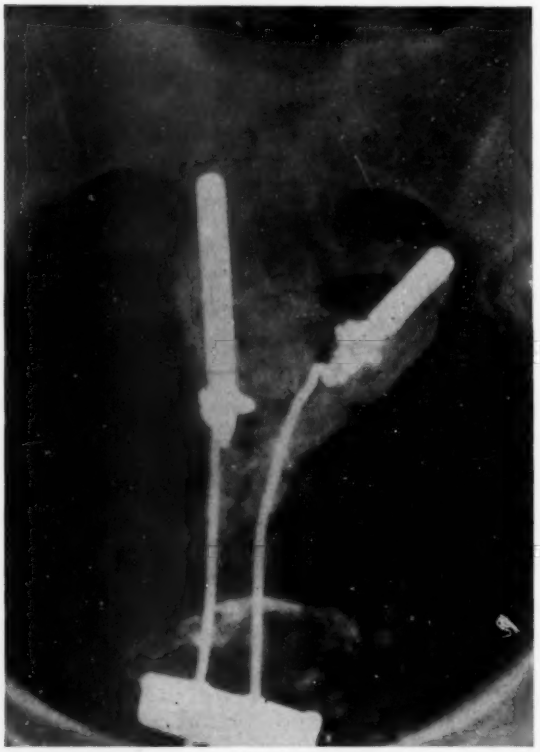

FIG. 6. Hysterogram of same patient as in Figures 4 and 5. Satisfactory radium application.

FIG. 7. Hysterogram of pregnant uterus.

dentation is present, due to the bulging of a mucous fold. This is most frequent on the upper margin of the fundus, and naturally is more marked in the thick premenstrual mucosa.

The endometrial relief shows a marked variation with the different stages of the menstrual cycle. The postmenstrual mucosa usually shows little detail. The whole uterine cavity shows a uniform shading with occasional flecks of coagulated thorium hydroxide (Fig. 1, *A*). Similar findings are present with any condition with a low flat endometrium, as after curettage and menopause.

The premenstrual mucosa shows a coarse folding. The folds have a tendency to a longitudinal arrangement. They are manifest by transparent areas surrounded by coagulated medium. They may be separated by rather wide intervals (Fig. 1, *B* and *C*). Naturally, all intermediate stages between the postmenstrual and premenstrual conditions are found.

Hyperplasia gives an exaggeration of the picture of the premenstrual mucosa (Fig. 2, *A*). The whole cavity of the uterus shows a coarse reticulated appearance. The longitudinal arrangement is less marked than with the normal premenstrual mucosa. The uterine contours are usually smooth, differing from corpus carcinoma. The process usually involves the entire cavity.

Mucous polyps give annular shadows with a transparent center, due to a ring of coagulated material about the polyp (Fig. 2, *B*). These are usually small. They cannot be differentiated from small submucous fibroids.

Submucous myoma produces a rounded, sharply defined filling defect (Fig. 2, *C*). The mucous membrane over it is smoothed and flattened. Intramural fibroids produce extensive deformities of the uterine cavity but without any localized rounded projections. Subserous growths have no effect on the uterine cavity, except possible displacements.

One endometrioma has been demonstrated as a filling defect. Its margins were not smoothly rounded and sharply defined as a submucous fibroid and its surface was more irregular.

The findings in carcinoma vary with the stage of the disease. Early carcinoma before ulceration appears gives a filling defect with an encroachment on the lumen. This may be relatively smooth in the cervical canal (Fig. 3, *A*), but usually rather ragged in the body (Fig. 3, *F*). With ulceration, an enlargement of the cavity appears in the involved area (Fig. 3, *B*). If ulceration appears early, a small crater is shown with elevated margins. This may appear in profile as a niche with elevated margins (Fig. 3, *D*), or on the anterior or posterior wall as a dense area surrounded by a transparent zone (Fig. 3, *E*). With extensive involvement, dense flecks appear outside the enlarged lumen, due to coagulated thorium in crevices of the ulcerated surface (Fig. 3, *C*). These indicate an extensive involvement and the danger of fistula formation following irradiation.

The normal folds of mucous membrane are obliterated by the carcinoma. Corpus carcinoma gives a coarse mottling similar to hyperplasia, but usually the contours of the uterus are more ragged and irregular with carcinoma. Hyperplasia involves the entire cavity, while carcinoma is a localized lesion, at least in its early stages.

Naturally, a roentgenographic method is not needed for the diagnosis of cervical carcinoma, but valuable information is obtained as to the extent of the lesion and the depth of ulceration. For carcinoma arising in the cervical canal or body of the uterus, the procedure may be diagnostic. It at least indicates suspicious points, which should receive special attention at curettage. It is not a substitute for curettage but rather a supplement as it shows the location and extent of a lesion.

Injection of thorium hydroxide before radium application gives an exact control of the position of the radium in relation to the lesion. Figure 4 shows a corpus carcinoma, confirmed microscopically. Figure

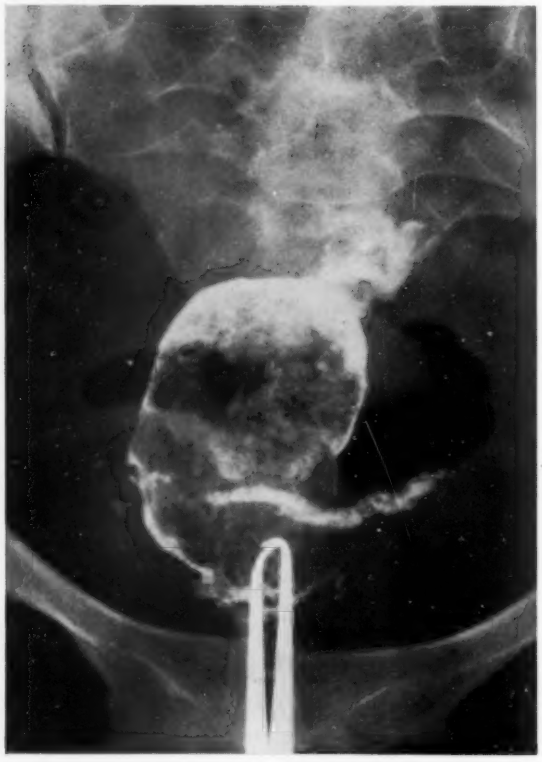

FIG. 8. Hysterogram of abortion in progress. The cervical canal is distended by the ovum while the cavity of the body has returned to its non-pregnant form.

5 shows an attempt at radium application. Both tubes lie side by side instead of one in each cornu as was intended. If the position of the tubes had not been changed, the unoccupied cornu would have received insufficient radiation. Figure 6 shows a second attempt with a satisfactory result. Without this control, it would have been impossible to determine the relation of the radium to the tumor.

The use of thorium hydroxide in the pregnant uterus is not to be advised, as it has been followed uniformly by abortion. The few patients injected have had indications for therapeutic abortion. The findings are quite definite (Fig. 7). The uterus has lost its triangular outline and become oval. The site of the ovum is indicated by a filling defect. The decidua gives a very coarse, ragged mottling. One patient was injected during the expulsion of the ovum (Fig. 8). The cervical canal is distended by the ovum, while the cavity of the corpus has already returned to its non-pregnant triangular form, showing the segmental nature of uterine contractions.

FISTULAE AND SINUSES

The thorium solutions coagulate with serum proteins and form an adherent opaque coating on the walls of sinus tracts and fistulae. The adhesion of the thorium hydroxide makes it possible to remove the syringe following injection, and place the part in any position desired, without any danger of the solution running out. The low viscosity of the solution permits it to penetrate much smaller openings than opaque oils and bismuth paste. For this reason, sinuses have been shown which could not be outlined with thicker media (Fig. 9). The use is practically painless. Drainage from the sinus is usually increased for several days after its use, and this tends to aid in the removal of the thorium. With extensive tracts, especially large cavities with narrow drainage channels, the coagulated thorium may remain indefinitely.

FIG. 9. Sinus injected with 36 per cent thorium hydroxide, with small channel communicating with rectum and numerous external openings. The rectum is well outlined by the solution reaching it through the narrow channel. A previous injection with bismuth paste failed to show many of the smaller channels and gave no evidence of a communication to the rectum.

The uterine solution of 18 per cent thorium hydroxide gives satisfactory shadows in tracts of large diameter. For narrow tracts of only 1 or 2 mm. in diameter, double this strength is more satisfactory, as the higher concentration of thorium gives a denser shadow. Solutions of about 50 per cent thorium hydroxide coagulate into such a stiff jelly that they may defeat their purpose and block a narrow channel before it is completely filled.

A sinus tract which is epithelialized with little secretion or with a secretion poor in proteins may fail to coagulate the solution.

OTHER USES

These colloidal solutions do not coagulate in the stomach. A mucous membrane relief of the colon can be obtained, but with the large quantity needed the expense becomes prohibitive. There is no satisfactory coagulation in the nasal accessory sinuses, esophagus, bladder or urethra. Possibly a preliminary washing with an alkaline colloid solution may give a mucous membrane relief of these cavities.

SUMMARY

Thorium hydroxide peptized by thorium nitrate forms an opaque coagulum with proteins in an alkaline medium. The coagulum forms a coating on the wall of a viscus and permits the roentgenographic demonstration of the relief of its mucous membrane. The medium does not coagulate in an acid medium, or with secretions poor in proteins. This makes it unsuitable for some body cavities, though this handicap may be overcome. Its chief use has been in the uterus and in sinus tracts and fistulae.

THE "DOUBLE-ORAL" METHOD FOR CHOLECYSTOGRAPHY*

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CHOLECYSTOGRAPHY is still new enough to be subject to numerous modifications. In our efforts for improvement two considerations should be kept in mind: one, gratitude toward the originators of this valuable test, and two, that modification should offer a definite advantage.

The first important development of cholecystography was the "oral method," which came from two independent sources.[11,16] The intravenous method was good, though it was obvious that if cholecystography were to be widely used by roentgenologists a simpler method had to be devised. But there were difficulties to be overcome with oral administration. Giving of the powder or solution to dogs was followed by immediate vomiting. The same happened with volunteers among interns at the Peter Bent Brigham Hospital. The stomach had to be protected from the irritant action of the drug. Enteric coatings were devised. The number of pills or capsules was so large that they had to be given in divided doses. Also it was believed that administration of smaller amounts of the drug over an extended period would produce less disturbance of the gastrointestinal tract, and favor more complete absorption. The principle of the divided dose is as old as oral cholecystography.

It was then found that by reducing the drug to a colloidal form[3] or to a non-irritating, finely divided precipitate by treatment with fruit acids[10] the necessary amount in one dose was well tolerated.

A serious fault of the oral method had been faintness or absence of shadow with gallbladders which proved to be normal, the difficulty arising from failure of absorption of sufficient amounts of the drug.

The idea of spreading divided doses over a period of several days, with the object of producing denser shadows, appears to have originated with Sandström.[12] He aimed, by resorption from the intestine and maintaining an increased concentration of the drug in the blood over a period of several days, to obtain intensity of shadow. Sandström apparently did not attempt to prevent emptying of the gallbladder, and allowed the patient to eat mixed foods.

Prevention of emptying of the gallbladder between these divided doses, without the necessity of fasting, by giving only carbohydrate food, was a modification of this method by Whitaker and Ellsworth.[19] It was suggested by experimentation which showed that pure carbohydrate foods have no effect in emptying the gallbladder in man.[13] From these sources the "double-oral" method was developed.[19]

With the necessity for simplicity in mind it was decided that the number of doses could be reduced to two of the full amount, the first following an ordinary meal, the second a carbohydrate meal. The use of prepared mixtures which require no addition except water was preferred. And it seemed that the time could be comparatively shortened without reduction of effectiveness.

Modifications including the "double oral" method will be discussed:

1. Decholin-sodium may be injected intravenously following roentgenograms made fourteen hours after oral administration of the drug.[7] Being choleretic it produces rapid distention of the shadow which indicates a normal wall of the gallbladder. The normality of the wall, however, can be just about as well determined by its contractability after a fat-meal.[13] There are other applications of the choleretic action

* From the Evans Memorial and the Massachusetts Memorial Hospitals, Boston.

of decholin-sodium in cholecystography which are under investigation by various workers.

2. "Rapid" cholecystography through the concurrent intravenous injection of glucose with the drug has been considered advantageous by Antonucci.[1] It is not so definite, however, what the advantage is. Intravenous injection is an inconvenience, and unless the accuracy is increased there would seem to be no good reason for the method.

3. Stewart and Illick[14,15] have devised a modification, which is a combination of several others, called "intensified" oral cholecystography. It embraces the slow method of Sandström, the "rapid" method of Antonucci, and also uses the prevention of emptying between doses by giving only carbohydrate foods.[19] For several reasons the method would seem to be unnecessarily complicated and prolonged. This increases the difficulty with patients who cannot or will not carry out a set of directions accurately, and with impatient roentgenologists who wish to obtain the best results at a minimum of time, effort and expense.

"Intensified" oral cholecystography depends upon two factors, both largely theoretical: first, a prolonged period for increased concentration of the radiopaque substance in the gallbladder, and second, administration of large amounts of sugar to facilitate its excretion by the liver.

In the first place there is a limit to the concentrating power of the gallbladder, both in time and degree. Elton and Deutsch[2] have shown that in cats and dogs practically no increase of concentration, either of bilirubin or total bile solids, is to be expected after twenty-four hours. We know that when the gallbladder becomes distended to a certain point very little bile will enter, and also, that normally there is a slight overflow from the distended gallbladder through "elastic recoil"[5] which would prevent retention of its contents for an indefinite period. Different observers have even noticed spontaneous emptying of the gallbladder, which is apparently not simply an overflow, but involves contractions of its musculature.[6,18] Oils having a viscosity similar to that of bile will not remain in the gallbladder for an indefinite period, even though the animal is fasting and active contraction does not apparently occur.[17] I have found that in dogs intravenous injection of tetraiodophenolphthalein after one day of fasting gives good shadows. This is probably made possible through slight, more or less continuous, influx and reflux of bile. Then it would seem that efforts to increase concentration in the gallbladder beyond twenty-four hours are useless. *The most important considerations would be to furnish an ample amount of the drug for the period of twenty-four hours, and to inhibit active emptying of the gallbladder as far as possible during that time.*

There is something to be said, also, upon the question of giving large amounts of sugar for the purpose of facilitating excretion of the drug by the liver, and thereby improving the shadow. The liver is an organ which has a huge factor of safety, and even though considerably damaged, is able to excrete the drug in sufficient amounts. I have found that tetraiodophenolphthalein in large doses is not damaging to the liver histologically, even if often repeated. Also, it has been demonstrated that in the dog the liver may be damaged by chloroform to the extent of fatty degeneration of about half the liver lobule and still allow formation of a good gallbladder shadow after injection of the drug.[4] It would seem, then, that no special protective action by glucose is necessary. Furthermore, density of shadow in the cholecystogram does not depend upon increased excretion of the drug by the liver, but upon concentration in the gallbladder. As shown above, this is limited. Consequently, it would appear that while administration of sugar in ordinary amount may be beneficial in a general way, the giving of large amounts is not especially helpful, and may be obnoxious to the patient who has a tendency to nausea. Administration

of more sugar than can be readily assimilated is certainly not indicated.

4. The "double-oral" method. In 1931, the "double-oral" method of cholecystography was published.[19] It has been used with great satisfaction in several hundred cases at the Massachusetts Memorial Hospitals. It employs the principles of (*a*) the divided dose; (*b*) the prolongation of the time for absorption of the drug,[12] and (*c*) the knowledge obtained from experimentation, that carbohydrate foods do not provoke contraction of the gallbladder in man.[13] Instead of administering small doses over several days it was decided to simplify the test by giving two full-sized doses. Also, in order not to prolong the time unduly, twenty-four hours was arbitrarily decided upon as the time limit. We learned later that no further concentration is to be expected after that. It should be kept in mind continually that a simplified method is necessary to secure proper execution.

A description of the "double-oral" method follows:[19]

> At noon the patient takes an ordinary meal. Immediately afterward a regular dose of sodium tetraiodophenolphthalein (4–5 gms) prepared for oral administration is given. Following this, nothing but water is taken by mouth until 7 or 8 P.M., when a carbohydrate meal is given consisting, for example, of dry toast or white crackers, any fruit or fruit juice, clear tea or coffee and sugar. A second regular dose of the drug is then administered, following which nothing but water is allowed, the roentgenologic study being made the next morning.
>
> The advantage of this arrangement is that the patient's routine is little disturbed. After taking the first dose at noon the day before the examination, he can usually continue his work during the afternoon. With some there may be nausea or vomiting and slight abdominal cramps associated with catharsis. Contrary to expectation, these symptoms are not generally aggravated by the second dose. The patient must be made to understand the directions perfectly, a printed copy of which should be given him. When he presents himself for examination he should be questioned on every point in order that we may know how much dependence can be placed upon the test. Control of the patient is a necessity for reliability.
>
> If a good shadow of the gallbladder is obtained, very well. The uncertainty comes when no shadow, or a very faint one, is visible. Then, to make this significant, we must be sure that the patient took all of the drug prescribed; that he did not vomit too much of it; that he ate no fat or protein after the first dose; and that purgation was not so marked that there was a probability of too rapid elimination of the drug.

To avoid excessive intestinal peristalsis, with cramps and diarrhea, 1–2 drachms of paregoric may be given after each dose of the drug.

If roentgenograms at the end of twenty hours show no shadow, or a very faint one, another carbohydrate meal may be given, followed by a third full dose of the drug, allowing as much additional time as seems necessary to insure a definite result. The advantage of this modification would be that ordinarily the decision can be made by the simple "double-oral" method, reserving the triple dose for the few doubtful cases. This would avoid subjecting all the patients to the prolonged regimen advocated by Stewart and Illick.

Stewart and Illick point out that with their "intensified" oral method the shadows are dense enough to allow examination under the roentgenoscope. In 1930, Dr. George Levene, roentgenologist at the Massachusetts Memorial Hospitals, began to use roentgenoscopy of the gallbladder ("cholecystoscopy") routinely, chiefly with the intravenous method. Much valuable knowledge has been gained thereby.[8,9] Dr. Levene tells me that in the great majority of cases the "double-oral" method allows shadows of sufficient density to perform "cholecystoscopy." He maintains, however, and I am inclined to agree with him, that, after all, the intravenous method is the best for ultimate reliability. However, no method is infallible; I have seen a patient in whom intravenous cholecystography revealed no shadow, who, upon cholecystectomy, had a histologically normal gallbladder full of concentrated bile.

CONCLUSIONS

Efforts at improvement of cholecystography should continue.

Comparative studies of all methods should be made by those who have the clinical material and facilities.

For the ordinary user that method is preferable which is simplest, most easily executed, conforms best to physiological principles, and withal carries a high degree of effectiveness.

The "double-oral" method for cholecystography is hereby recommended:

(1) One full dose of the drug following an ordinary noonday meal.

(2) Another full dose following a carbohydrate supper.

(3) If a questionable shadow is present next morning, another carbohydrate meal and another full dose of the drug may be given.

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GIANT RUGAE (LOCALIZED HYPERTROPHIC GASTRITIS) RESEMBLING CARCINOMA

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THE object of this communication is to put on record two cases of giant rugae in which the roentgen appearance suggested carcinoma. The diagnosis was confirmed by operation in both patients.

Ordinarily, rugae are not visible in the completely filled stomach or in the erect posture. For their demonstration a minimum filling with a small amount of barium and usually some form of compression are required. The compression involved in the prone posture suffices in some cases; in others additional pressure is needed as by the balloon belt of Chaoul. Along the lesser curvature the rugae run in parallel lines and thus do not disturb the periphery, but on the greater curvature the folds approach the gastric outline obliquely or even at right angles and so cause irregularities to which the terms serration, corrugation, fibrillation, crenation or crinkling have been applied.

When these markings are within ordinary limits, they are readily recognized as being due to gastric rugae.* When, however, their size and depth increase it becomes correspondingly difficult to differentiate the resulting roentgen picture from a filling defect due to carcinoma. This difficulty has already been pointed out, but as far as I can make out all the writers with the exception of Cole[3] have been Europeans (Berg,[1] Chaoul,[2] Scherer,[6] Weltz,[7] Windholz[8]) and hence their contributions are not so well known as they might be in this country. The situation is further complicated by the fact that such a picture may indeed be due to carcinoma, whether intrinsic, or, as in Chaoul's case, due to peritoneal metastases. Moreover, as Cole suggests, the size of even normal rugae is likely to be exaggerated by modern methods of mucosal visualization, especially when compression technique is utilized. In short, it would appear that we are more and more likely to be confronted with this particular diagnostic problem.

Hypertrophic gastritis has long been known to pathologists, but it is only since the introduction of modern diagnostic methods such as gastroscopy (Gutzeit[5]) and roentgen study of the gastric mucosa that the condition has been positively recognized clinically. Judging from the available experience, the incidence of localized hypertrophic gastritis (giant rugae) seems to be rare. Windholz found 2 cases in 3,000 autopsies, Cole and Scherer each reported 4 cases, Weltz described 2, and I have encountered 2 cases in over 2,500 patients examined roentgenographically. Illustrations of resected or post-mortem specimens may be found in most of the articles quoted.

CASE REPORTS

CASE 1. Female, aged fifty-seven, seen in November, 1925. Intermittent cardiospasm with regurgitation for ten years. Actual weight 95 lb , ideal weight 141 lb.

Roentgen Examination. Typical dilated esophagus with retention for at least six hours. The stomach showed a very extensive filling defect along the greater curvature (Fig. 1). No mass was palpable corresponding to the filling defect; there was no anemia; the Wassermann test was negative. Three more examinations within the next two months revealed no essential change in the roentgen picture. The final opinion was that we were probably dealing with hypertrophied gastric mucosa rather than with carcinoma. In view of the failure of conservative treatment to relieve the cardiospasm operation was advised.

Operative Findings. March 19, 1926, by Dr. A. A. Berg. Palpation of the stomach revealed

* Although Cole[4] says: "The folds on the greater curvature of the corpus are very frequently interpreted as the finger prints of carcinomatous infiltration and have led to more erroneous roentgenologic diagnoses than any other single finding." Loc. cit., p. 147.

some thickening corresponding to the roentgen findings. On opening the viscus hypertrophic folds of mucosa were seen along the greater curvature; there was no neoplasm. A Ramstedt operation was performed on the cardia.

Case II. Female, aged seventy-two, seen March 4, 1935. Marked family history of carcinoma: one brother (former patient) died of cancer of the stomach, mother of cancer of the liver, sister of cancer of the throat. Patient has cancerophobia and worries about enlargement of abdomen. There is long standing constipation and cathartic habit and a history of previous hypertension. There is no real story of failing digestive compensation. Physical examination reveals sthenic habitus, good nutrition, a large flabby abdomen difficult to palpate. On one occasion a mass was believed to be present in the left epigastrium but this was not confirmed by subsequent examination. The anal sphincter was spastic and painful. Test meal: free HCl 16; total acidity 44. Hemoglobin, 80 per cent (Sahli, normal).

Roentgen Examination. Stomach normal in erect posture (Fig. 2). In the prone position there is a "filling defect" along the greater

Fig. 1. Case I. Prone posture. Standard technique (no compression). Note extensive and deep area occupied by hypertrophic rugae (*F. D.*).

Fig. 2. Case II. Erect posture. Standard technique (no compression). Note integrity of greater curvature outline.

curvature for a distance of 2 inches (Fig. 3). The greater part of this is most likely due to spine pressure but the proximal angle has a suspiciously irregular appearance. In order to study this region more carefully a mucosal visualization was done with the aid of the compression belt of Chaoul. The result was the definite filling defect shown in Fig. 4. This was interpreted as probable carcinoma.

At this point additional information came to light which still further complicated the problem. Dr. M. Wolk reported that four years ago the patient had consulted him and complained of the same trouble (enlarged abdomen). Roentgen examination at that time by Dr. H. Besser showed an apparent filling defect of the posterior medial surface of the stomach, which on re-examination was attributed to "a marked accentuation of the rugae." Inspection of the films made at that time revealed a "filling defect" located in the same region as the present and characteristic of gastric rugae.

A consultation was then held (Drs. F. C. Wood, A. A. Berg, M. Wolk, and myself) at which it was decided to perform an exploratory laparotomy for the following reasons: (1) the

Fig. 3. Case II. Prone posture. Standard technique (no compression). Note irregularity of middle portion of greater curvature (*F. D.*).

strong family history of carcinoma, (2) the unusually "organic looking" filling defect produced by the mucosal visualization compression belt technique, (3) the possibility that, even if we were dealing with hypertrophied mucosa, a malignant degeneration might have taken place in the four years intervening between the two roentgen examinations, (4) the desire on the part of the patient and her family to put a quick end to the doubt whether carcinoma really existed or not.

Operation, March 14, 1935, by Dr. A. A. Berg. The abdominal cavity was free from fluid and metastases. On the middle of the greater curvature of the stomach, exactly corresponding to the suspicious area in the film the serosa showed an unusual whiteness for an area some 2 or 3 inches in diameter. This area involved both surfaces at that level and faded gradually into normal colored tissue beyond. The involved wall was somewhat thickened, but did not feel neoplastic. On opening the stomach the underlying mucosa was found to be markedly hypertrophic, the rugae consisting of huge gyri, presenting the general appearance and arrangement of cerebral convolutions. Examination of a piece of this mucosa by Dr. P. Klemperer showed "chronic hypertrophic gastritis; no evidence of tumor."

The patient made an excellent postoperative recovery. She was alive and well when heard from in January, 1936.

COMMENT

These cases illustrate the difficulty of diagnosis in the presence of marked hypertrophic gastritis (giant rugae). On first thought, indeed, the roentgenogram would seem to be misleading, particularly because the modern method of mucosal visualization is better equipped to reveal suspicious filling defects than is the original full barium meal procedure. As a result we are lifted between the horns of a dilemma, since it is just this type of service—the early demonstration of small filling defects, *before* the appearance of "characteristic signs and symptoms" of neoplasm—that is one of the chief contributions of roentgen diagnosis.

Fig. 4. Case II. Prone posture. "Mucosal visualization" technique, with compression balloon (heavy circle). Note type of filling defect produced by giant rugae (arrows).

The answer to our difficulty would appear to be two-fold. First, we must learn, once again, that hypertrophic gastritis is just as real a clinical and pathological entity as are the other organic lesions that have recently been dominating our attention. Secondly, we must learn to recognize the roentgen appearance of giant rugae—hence the desirability of publishing roentgenograms of proved cases—and try to differentiate them, if possible, from filling defects due to carcinoma. If such a decision cannot be made from a single observation, and it would appear to be extremely difficult in some cases, we must employ the principle of repeated re-examinations at frequent intervals, with rigid observation of the clinical course of the patient during the interval of watchful waiting. Even so, it is likely that, for some time at least, exploratory operation will be unavoidable in some cases.

SUMMARY

1. Two cases of giant rugae (localized hypertrophic gastritis) are described and the roentgen appearance illustrated.

2. Both cases showed resemblance to carcinoma, yet both were proved benign at operation.

3. In the presence of similar roentgen findings the differentiation between carcinoma and hypertrophic gastritis may be made by repeated roentgen observations with careful correlation of clinical findings. However, in certain instances, exploratory operation may nevertheless prove unavoidable.

4. Exploratory operations may be minimized in the future by better acquaintance with the clinical, pathological, and especially, the roentgen, manifestations of advanced localized hypertrophic gastritis.

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PAPILLOMA OF THE DUODENUM

REPORT OF A CASE

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IN A recent article on the roentgenologic diagnosis of duodenal papilloma, Waters[1] reviews the literature to date, describes the characteristic findings and reports a very interesting case of his own in which he made the correct diagnosis roentgenologically. He notes that of all the cases of benign tumor of the duodenum reported, only 4, including his own, had been correctly diagnosed roentgenologically.

Films of the following case were exhibited at the New Orleans meeting of the Radiological Society of North America in December, 1927, but the case has not been formally reported. On account of the rarity of the condition and the characteristic findings in this case it would seem desirable to place it on record.

CASE REPORT

J. W. M., male, aged fifty-five, was referred by Dr. J. A. Lepak on October 24, 1927, for examination of the gallbladder and gastrointestinal tract. The patient has complained of stomach discomfort off and on for years; has led a very strenuous life; sleeps poorly; uses considerable alcohol and tobacco. Beginning about September 15, 1927, he had a severe gastric upset, appetite failed and he developed discomfort in the epigastrium and in the right upper quadrant. This was not related to food.

Physical Examination. Essentially negative as to the abdomen.

Roentgen Examination. The Graham-Cole test showed a poor gallbladder shadow and delayed emptying and was interpreted as probably indicative of a pathological gallbladder.

The following quotation pertaining to the stomach and duodenum is from my report dated October 26, 1927: "The stomach is in good position, normal in size and shape and empties fairly well under observation. The entire stomach is normal in appearance except the immediately prepyloric portion, which, in the first fluoroscopic examination and in the first serial films, showed a peculiar filling defect. Two additional fluoroscopic examinations with an opaque meal and additional serial films apparently exclude any lesion of the stomach. Emptying takes place fairly freely. The duodenal cap shows constantly a very peculiar filling defect. The appearance is not that of a duodenal ulcer, although the external contour shows some deformity. The appearance also is not that of an air bubble which is frequently seen in the duodenal cap, but is rather suggestive of a polypoid condition or soft tumor within the cap. No evidence of any mass or tumor pressing from behind could be made out on careful palpation under the fluoroscope. The appearance is not suggestive of adhesions and is more or less the same in the first and subsequent fluoroscopic examinations and films, changing somewhat in different positions of the patient. The remainder of the duodenum is negative. . . . Conclusions: Very peculiar appearance of duodenal cap, suggestive of a soft polypoid tumor within the lumen. Duodenum otherwise negative."

Figures 1 to 3 show the characteristic roentgenographic appearances, upon which and the similar roentgenoscopic findings, the report was based.

The patient was operated upon November 22, 1927, and a very soft, papillary, fimbriated tumor found, arising from the pylorus and from an area extending about 1 cm. to the distal side. Dr Arnold Schwyzer, who performed the operation, describes the findings as follows: " . . . The area of the pylorus and upper duodenum feels fleshy and a tumor of very soft consistency is made out which can be pushed through the pylorus into the stomach. After walling off and tying the stomach with a catgut toward the left side, the stomach is opened about 4 cm. and the very fluffy, soft papilloma is readily seen. Its pedicle is at the pylorus and about 1 cm. downward, perhaps 1.5 cm. The pylorus is lifted up by pulling on the tumor. . . . With a small retractor in the pylorus we grasped the pedicle with fine artery forceps and cut the tumor away, which when

[1] Waters, C. A. The roentgenologic diagnosis of papilloma of the duodenum. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *24*, 554–557.

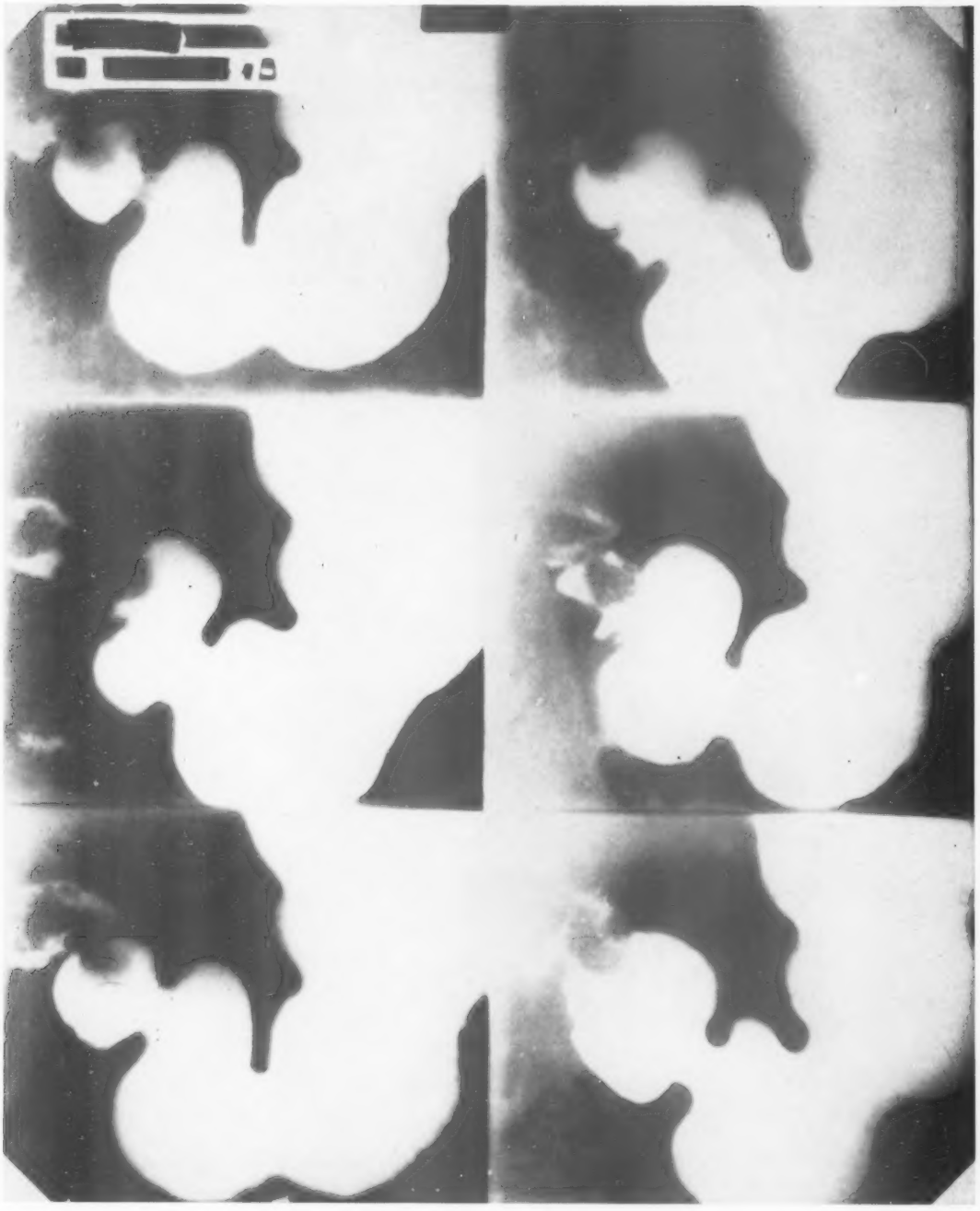

Fig. 1. Appearance of papilloma when projecting partly through the pylorus into the stomach.

pulled out is about 5 cm. long and about the thickness of the middle finger or thumb (Fig. 4). . . . That it is a duodenal tumor is proved by the fact that we had to go through the pylorus which was lifted into the outer stomach wound in order to get at the pedicle which ran from the pyloric area downward."

The gallbladder was diseased and adherent and was also removed.

Pathological Report. A papilloma with a regular arrangement of epithelium everywhere.

Diagnosis. Benign papilloma.

Patient recovered and was well in November, 1930.

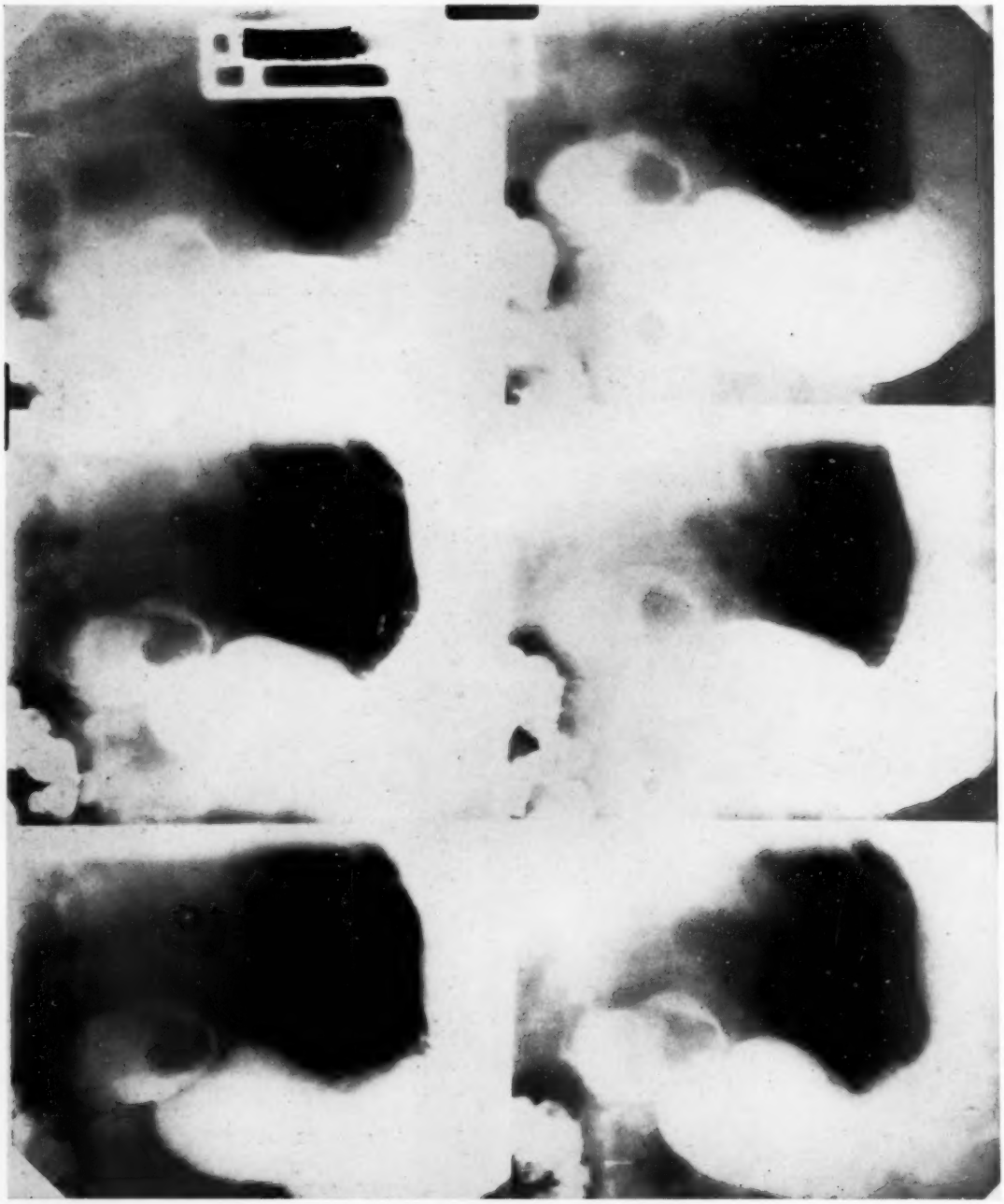

Fig. 2. Papilloma in the duodenum.

COMMENT

It is interesting to compare Dr. Schwyzer's statement, that the tumor could be pushed through the pylorus into the stomach, with the roentgenoscopic and roentgenographic findings at the first examination (see Fig. 1), where there was a definite filling defect both on the proximal and the distal side of the pylorus. The prepyloric filling defect was never present later, while the filling defect in the duodenum was constant (Figs. 1 to 4), showing the duodenal location of the tumor.

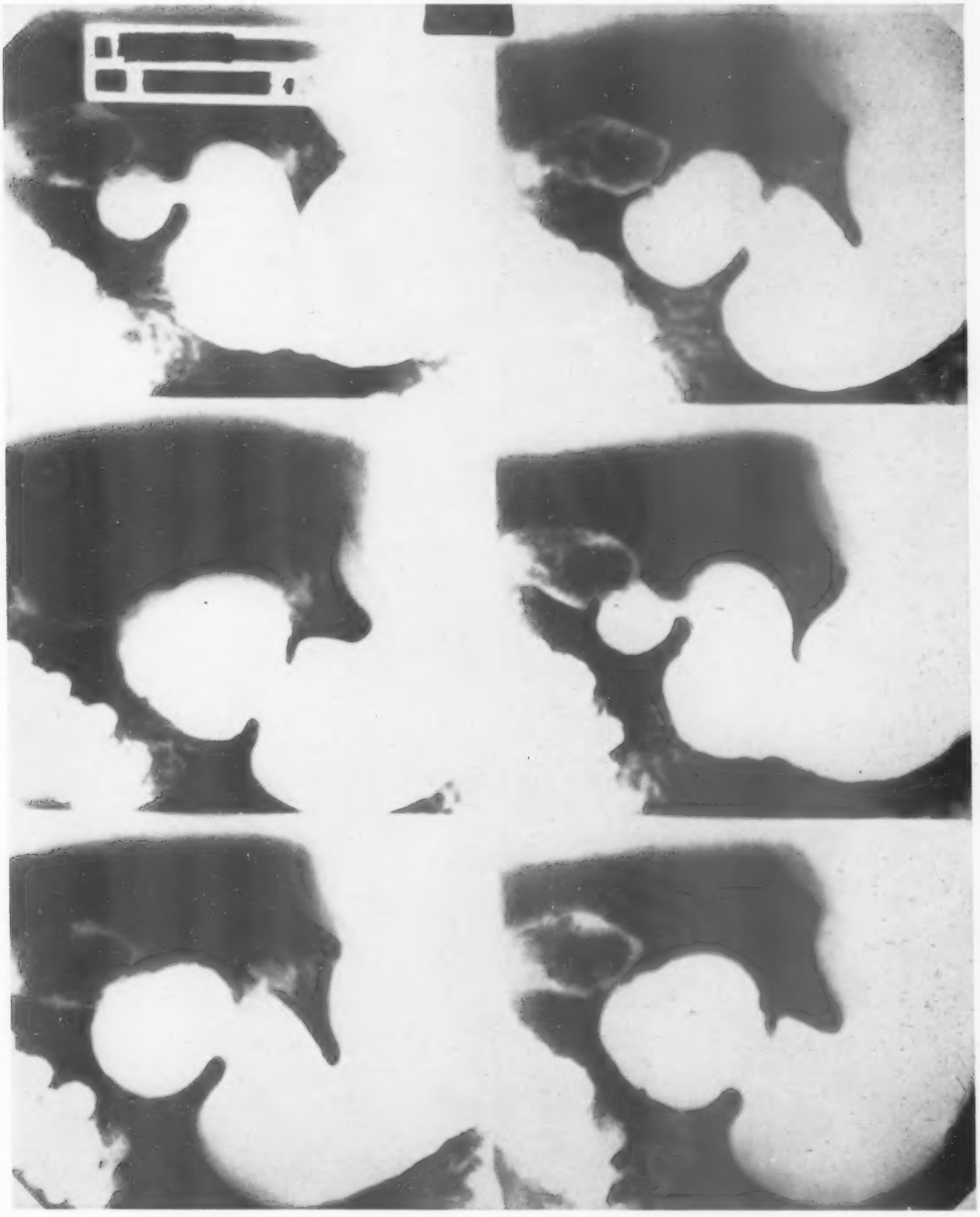

Fig. 3. More characteristic appearance of papilloma located entirely in the duodenum.

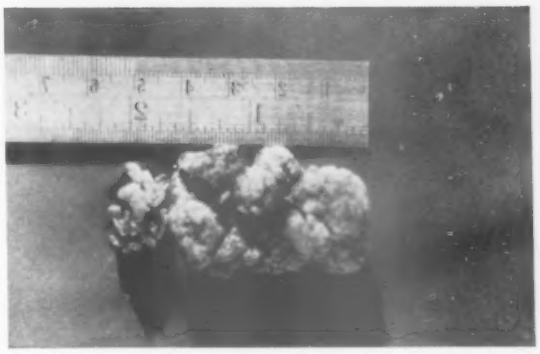

Fig. 4. Specimen after removal.

A CASE OF OSTEOPETROSIS (MARBLE BONES) COMPLICATED BY OSTEOGENIC SARCOMA*

By H. DABNEY KERR, M.D.
IOWA CITY, IOWA

THAT the condition first designated by Albers-Schönberg[1] in 1904 as "marble bones" (Marmorknochen) can still be classed as a rare disease is shown by the fact that in a recent excellent and comprehensive review of the subject by McCune and Bradley,[2] only 65 reported and apparently authentic cases could be found. To this series they have added their own case.

We wish to add to the series a recently observed case which showed generalized involvement and a complicating osteogenic sarcoma.

[1] Albers-Schönberg. Röntgenbilder einer seltener Knochenerkrankung. *Aertzl. Vereinald., Hamburg*, Feb. 9, 1904.

[2] McCune, D. J., and Bradley, C. Osteopetrosis (marble bones) in an infant: review of the literature and report of a case. *Am. J. Dis. Child.*, 1934, *48*, 949–1000.

CASE REPORT

J. G., male, negro, aged twenty, was admitted to the University Hospital July 18, 1934, with the chief complaint of pain and a tumor mass in the right thigh. The pain had begun three months prior to admission and had at first been in the calf of the right leg. It had then shifted to the thigh. At about this time he noticed a mass over the lower end of the femur, medially and posteriorly. The pain was characterized as a dull ache and was severe enough to keep the patient from sleeping. He also had had a vague shifting pain in his chest ever since the onset of the present illness.

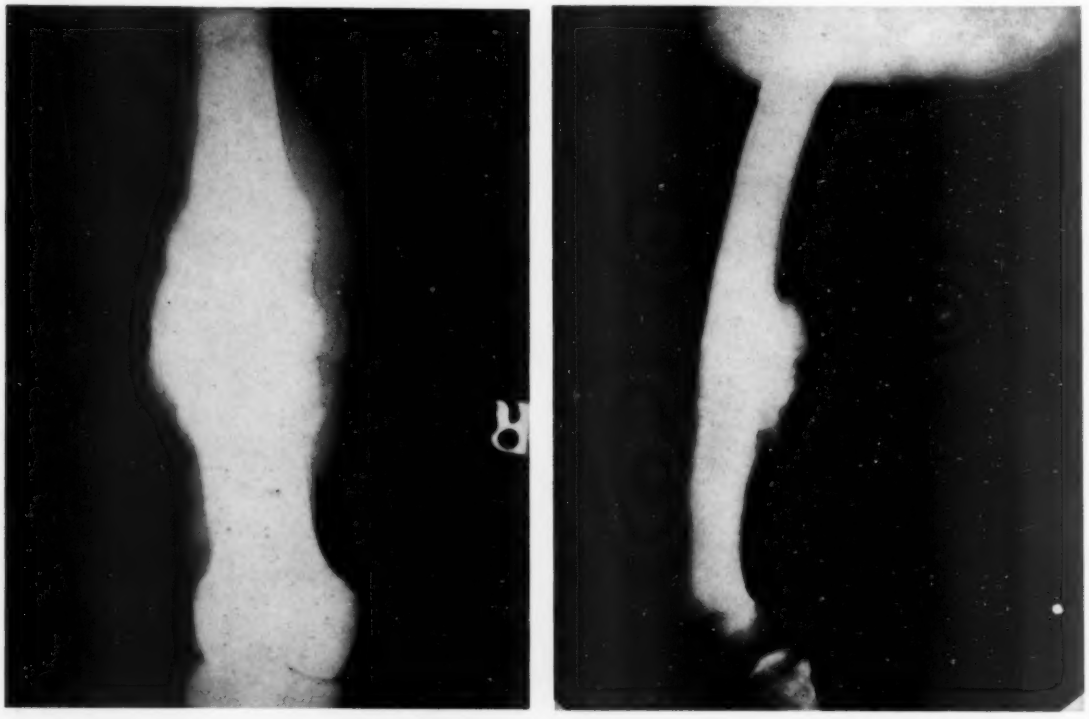

FIG. 1. Anteroposterior and lateral films of femur showing increased density and loss of bone detail with changes characteristic of osteogenic sarcoma.

The patient's head, as well as that of his father, had always been large. Patient did not learn to walk until about eight years of age. He finished the third grade in school.

* From the Department of Roentgenology, State University of Iowa, Iowa City, Iowa.

Physical Examination. Patient is a short, well-nourished male negro, twenty years old. The head is extremely large and measures 62 cm. in circumference. It is long and narrow and prominent in the frontal and occipital regions. The face appears sunken. The chest shows a rachitic rosary. Abdomen negative

Above the right knee is a bony hard mass presenting especially over the medial portion of the thigh. This mass appears attached to the femur.

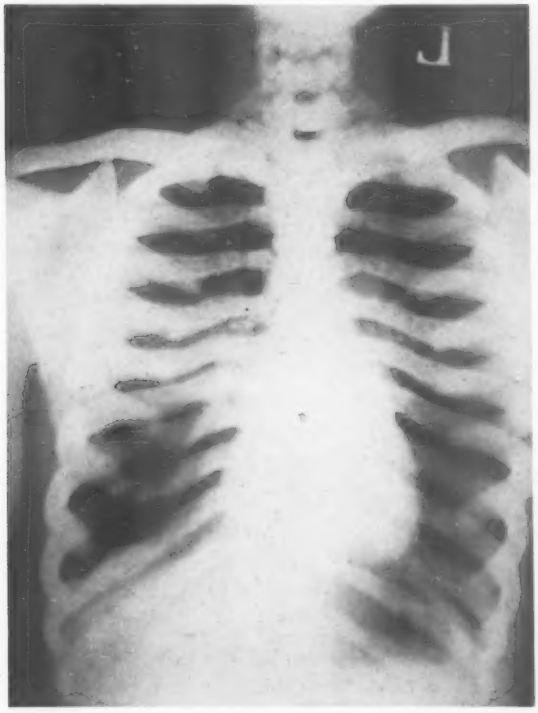

Fig. 2. Chest film showing metastasis in left midlung field and marked increase in density of all bones.

Roentgen examination of the right femur (Fig. 1) showed the bone to be abnormally dense throughout. Arising from the lower third laterally, posteriorly and also somewhat medially was an osseous mass which exhibited all of the usual roentgen criteria of an osteogenic sarcoma: the periosteum was elevated and ruptured, the new bone was for the most part laid down perpendicular to the shaft, the cortex was perforated but not generally destroyed and the medullary canal above the tumor showed evidence of widening as though by pressure and infiltration by a new growth. It must be noted, however, that the above information could not all be obtained from the first examination be-

Fig. 3. Lateral film of skull shows greatly thickened calvarium and base of skull, as well as general increase in size.

cause the density of the femur was so great that detail was not shown with the ordinary exposures. Additional penetration was necessary to bring out shaft and tumor detail. There was evidence also of a soft tissue tumor, con-

Fig. 4. Vertebral bodies are dense and without usual detail.

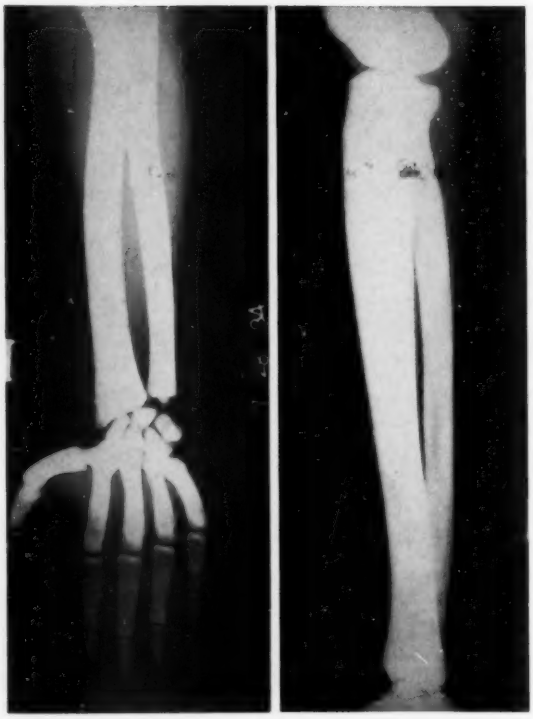

FIG. 5. Arm and leg show changes typical of "marble bones."

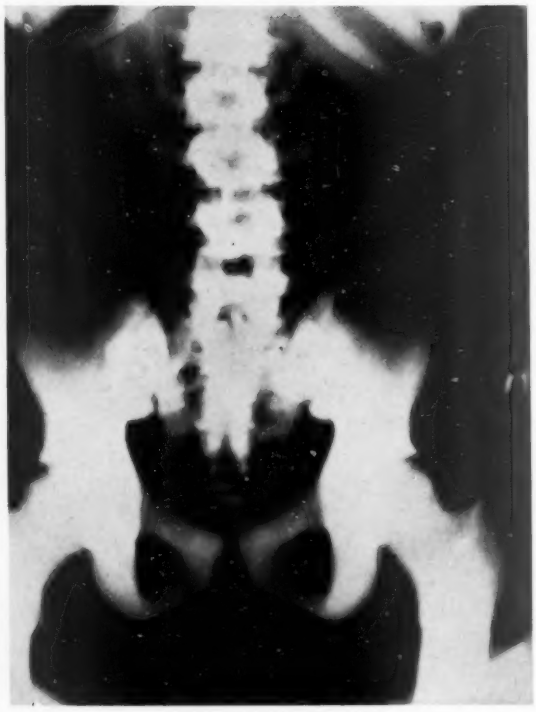

FIG. 6. Pelvis and lumbar spine are also markedly involved.

taining little or no calcium, lying beyond the limits of the femur and the bony mass.

Films of the chest (Fig. 2) taken to determine the presence or absence of metastases showed two small, rounded areas of increased density suggestive of secondary deposits in the lungs. The ribs, clavicles, scapulae and upper humeri showed a marked increase in density and, together with the findings in the femur, suggested an advanced stage of marble bones or osteopetrosis. Roentgen examinations were then made of the skull (Fig. 3), spine (Fig. 4), forearm, hand and leg (Fig. 5) and pelvis (Fig. 6). Each part showed changes characteristic of this condition. The skull, particularly, was enormously thickened throughout.

Impression. Osteogenic sarcoma of right femur, with probable pulmonary metastases; advanced skeletal changes suggesting marble bones.

Laboratory Findings. Red blood cells, 3,700,000; white blood cells, 5,400; Hb, 80 per cent; differential count—not remarkable. Wassermann and Kahn reactions negative.

Serum calcium	10.9 mg. per 100 c.c.
Serum phosphorus	3.5 mg. per 100 c.c.
Cell volume	35.0 mg. per 100 c.c.
Protein	6.75 mg. per 100 c.c.
Albumin	3.25 mg. per 100 c.c.
Globulin	3.50 mg. per 100 c.c.
Plasma phosphatase	32.8 units

Phosphorus partition	Whole blood	Serum
Total phosphorus	40.4	11.3
Total acid soluble P	29.6	4.2
Inorganic P	3.3	3.5
Lipid	11.1	7.1
Ester	26.3	0.7

Course. Because of the metastases in the lungs, it was considered inadvisable to amputate the femur and palliative irradiation was given for control of pain. Patient was returned to his home and nothing more was heard of him until recent inquiry revealed the fact that he had died in December, 1934.

SUMMARY

As far as can be determined from the literature, this is the first case of osteopetrosis reported in a Negro. Whether or not there was an admixture of Aryan blood could not be determined, but the patient was very dark.

No other reported case shows a complicating primary bone sarcoma.

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THE RELATIONSHIP BETWEEN ETHMOIDITIS AND OCULAR DISTURBANCES*

By S. L. KOCH, M.D., *and* J. HOMER McCREADY, M.D.
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THE nasal accessory sinuses play an important rôle in the production of diseases of the eye. The particular eye condition may be the direct result of a contiguous sinus inflammation or may be caused indirectly. When conjunctival, corneal or lacrymal inflammations are of nasal origin they are chiefly attributed to primary inflammation of the nasal accessory sinuses. Most interesting to the ophthalmologist is involvement of the uveal tract, retina, and optic nerve with the attending divergent groups of thought. Some maintain that a direct relationship exists between sinus inflammation and disease of the uveal tract, retina and optic nerve, while others hold that this relationship is indirect.

It is Zeim's opinion that some lesions, in the presence of nasal infection, develop indirectly from disturbance of physiological circulation which manifests itself as a passive congestion in the uvea. He regards choroiditis and vitreous clouding in the same way. It is also held by some that a sinus empyema acts as a predisposing factor in disease of the uveal tract.

It is not our intention to become argumentative, but to agree that the etiology in many eye inflammations is indirect. On the other hand, the literature over a period of years abounds in reports of cases of optic neuritis, neuro-retinitis and retrobulbar neuritis where the particular condition was relieved by nasal treatment, operation, or both. If in the presence of nasal pathology, proved by roentgen examination or local examination, the removal of it relieves the eye condition, one can hardly deny a direct relationship.

The adherents to the direct and indirect relationship theories are most emphatic in their opinion in cases of retrobulbar neuritis. Although there are a large number of cases reported in the literature in which relief followed nasal operation many do not admit of a definite association between the two lesions. Against direct relationship they place the absence of more than a very small amount of pathologic post-mortem confirmation. Many do not accept the cases of hyperplasia without pus formation.

In keratitis, iritis, uveitis, and choroiditis, the most common source of infections is in tonsils and teeth. When, however, the focus of infection is in the sinuses there is always a definite hyperplasia of the sinus mucosa and it is very often attended by an empyema. The maxillaries are the most frequent location of the source of infection with the ethmoids and sphenoids following in order of frequency. In these types of cases the roentgen examination is of utmost value, in that the roentgenograms show very definite pathology in the affected sinuses. In cases of hyperplastic maxillary disease it is often desirable to irrigate the antra. If no pus is obtained by irrigation, the instillation of lipiodol followed by a roentgenogram will in many instances show a very definite filling defect and thus prove a hyperplastic disease of these sinuses. Similarly, the ethmoids and sphenoids may be studied by the lipiodol displacement method of Proetz. However, in our experience this has not proved of as much value as many of our distinguished colleagues claim.

When the above condition exists and the diagnosis has been properly made, the treatment, of course, depends upon the type of case under consideration. If the ventilation of the nose is sufficient for good sinus drainage and there is not too much hyperplastic change in the mucosa of the sinuses, local treatment may be instituted with some benefit. If the ventilation of the

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

sinuses is obstructed by a deflected septum this should be corrected. While conservative treatment of maxillary disease, namely irrigation and intranasal windows, is advocated by some men we have usually found that more radical surgery has been necessary to completely eradicate the toxemia which is the cause of eye disorder. We prefer the Caldwell-Luc operation, when the maxillary sinus is involved, with as much intranasal ethmoid surgery as is indicated in the particular case under treatment. There is also an occasional case in which there is a marked hyperplastic pansinusitis which will respond only to the most complete type of surgery, i.e., an external fronto-ethmoidectomy accompanied by radical antrum surgery.

We have purposely omitted neuroretinitis, optic neuritis and retrobulbar neuritis in the above discussion because we feel that this group merits separate consideration.

The treatment of each case of neuroretinitis, optic neuritis and retrobulbar neuritis is a study in itself. Some are so mild that spontaneous recovery rapidly results. It would be a grave error to submit these types of cases to unnecessary surgical intervention. Often, however, cases, if left untreated, will not recover and atrophy will result. As long as the patient may be carefully examined at frequent intervals a reasonable delay is justified. If after a short time the appearance of the optic disc is unimproved or worse and the vision is diminishing, the case requires serious consideration. Every focus of infection which might be responsible for the condition should be carefully examined. It is always our custom to have the teeth and tonsils carefully checked and in all cases to have a thorough roentgen examination of the sinuses.

At this point we wish to call attention to the necessity of a very careful study of the films in this type of cases. When the above conditions are due to sinus involvement the ethmoids and sphenoids are almost always the affected sinuses. A slight hyperemia of the middle turbinate, together with a moderate degree of bogginess of mucous membranes over the ethmoidal labyrinth, is very often the only nasal finding. It follows that slight changes in the aeration of the ethmoids and sphenoid when found by the roentgen ray are of utmost help to the rhinologist. The roentgenologist should be alert to look for these slight changes and so report them. Gross pathology is the exception and not the rule.

The important rôle played by tonsils and teeth in these cases recalls two cases which we have recently seen. The first was a young woman who had a severe optic neuritis with considerable reduction of vision. The only source of infection which could be found was a pair of diseased tonsils. Removal of the tonsils brought about a prompt improvement with a return of vision to normal. The second was a case of very acute neuro-retinitis with excessive edema of the disc and retina, enormous venous engorgement, copious retinal hemorrhage. After the extraction of two infected teeth, improvement was noticeable in two days. The vision was normal in two weeks.

The greatest number of cases, however, in our experience have definite pathology in ethmoids or sphenoids or both, and unless this was properly dealt with the expected improvement did not ensue. The explanation of improvement may be based on the theory of removal of toxins within the sinus cavity or tonsils, or upon the anaphylactic theory of Stark in which he says, "The sensitization of the tissues of both the sinuses and the orbit by the bacterial proteins produces an allergy resulting in a localized anaphylactic reaction each time the individual comes in contact with a fresh infection of the same bacteria in the nose- teeth- tonsils or other parts of the body."

Whatever theory one may accept, it is an established fact that one is amazed at the meagerness of the macroscopic pathology which is encountered in these patients even though the operation is attended with startling improvement. The

rhinologist is expectedly hesitant in doing nasal surgery on cases with negative findings and so the responsibility of procedure justly falls on the oculist. His opinion is not only important but essential as the deciding factor in dealing with cases of optic nerve disease.

In orbital cellulitis or orbital abscess the direct relation to sinus infection is well established. In children this disease is always of ethmoidal origin while in adults it may be of either ethmoidal or frontal origin. In children local nasal treatment is occasionally sufficient. The presence of pus in the orbit is always an indication for incision and drainage. When surgery is contemplated on the ethmoids or frontals an external approach is preferred, with the removal of all necrosed bone and diseased cells but with the preservation of as many non-diseased cells as possible. In adults, because of various possible complications, an external operation of the Lynch type is advocated, with drainage of the orbit at the same time.

Experience has taught us that a broad viewpoint of all possible etiological factors is absolutely essential in dealing promptly and successfully with cases in the various groups described. Each case is an entity and must be treated as such. The active cooperation of the roentgenologist, rhinologist and oculist is very necessary in bringing many of these cases to a successful conclusion.

CONCLUSIONS

1. Tooth and tonsil infections play an important rôle in the production of disease of the eye.

2. Diseases of iris and uveal tract and choroiditis, when due to sinusitis, are attended by definite hyperplastic change in the sinus mucosa.

3. Neuro-retinitis, optic neuritis and retrobulbar neuritis, when due to sinusitis, may be accompanied by slight macroscopic pathology of the sinus mucosa.

4. Orbital cellulitis, when treated surgically, should be approached by the external route.

DIAGNOSIS OF TRAUMATIC LESIONS OF THE URINARY TRACT

WITH SPECIAL REFERENCE TO THE VALUE OF EXCRETORY UROGRAPHY*

By FRED O. COE, M.D.
WASHINGTON, D. C.

SINCE the advent of the automobile, traumatic lesions of the urinary tract have assumed a new importance. Statistics dealing with the frequency of such lesions are of little value as most of these date back to the latter part of the nineteenth or the beginning of the twentieth century. Küster's statistics, published in 1895, showed a frequency of 9 ruptures of the kidney in 7,741 cases with contusions. Judging by the number of cases reported by surgeons in different parts of the United States and Europe, in the recent literature, the proportion of cases of ruptured kidney has increased many fold. An injury which a few years ago was considered a rarity is becoming one of the more common. The roentgenologist, with his recently acquired means of accurate diagnosis of urinary tract lesions, must assume greater responsibility in such cases and be able to give valuable information as to treatment and prognosis.

The kidney, ureter or bladder may undergo traumatism from blows on the exterior of the body or as the result of penetrating objects. The first group is much the more common and they are the ones with which we shall deal. The second class is rare and can be regarded as a surgical curiosity. When the traumatism is due to external violence the integument is not usually broken and the injuries are spoken of as subparietal ruptures. The latter, according to Young's classification, are divided into (1) those due to direct violence, force applied over the site of the kidney; (2) those due to indirect violence, where the force is applied at a distance, as in a fall on the feet or buttocks; (3) those due to severe muscular effort. Rupture due to direct violence is by far the most frequent, although the literature contains reports of isolated cases clearly in the other two classes.

Küster's hypothesis as to the manner of of rupture due to direct violence seems the most plausible. It is as follows: "The hydraulic pressure, acting through the full vessels and the pelvis of the kidney, causes the organ to burst along the lines radiating from the hilum to the point of maximum impact against the ribs, the opposing resistance being supplied by the vertebral column." The severity of the injury is sometimes out of proportion to the degree of trauma. The case reported by Watson is often quoted, in which a man ruptured his wife's kidney while waltzing with her. Some authors stress the importance of preexisting disease of the kidney causing increased internal pressure while others think it is of little significance. As causative factors automobile accidents undoubtedly come first on the list, while industrial accidents, football and other strenuous sports add their quota. A good coasting snow in Washington last winter accounted for 3 cases in our clinics within a few days.

PATHOLOGICAL FINDINGS

The classification of Tuffier is usually adequate: (1) ecchymosis; (2) subcapsular rupture; (3) total rupture. Ecchymosis and subcapsular rupture are usually considered benign, the injuries being followed only by infarcts. Tuffier has shown that the exposed surfaces of the parenchyma do not secrete urine unless the pelvic cavity is opened. In subcapsular rupture there is a tearing of the

* From the Radiological Clinic of Drs. Groover, Christie and Merritt. Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.

kidney tissue, the capsule remaining intact. There is an outpouring of blood and also of urine if the calyces or pelvis is entered, with increase in the intracapsular pressure. When the intracapsular pressure equals the blood pressure the bleeding will stop. The blood and urine will in time be absorbed. The injured glomeruli and tubules cannot regenerate and hence are replaced by scar tissue.

In total rupture the blood and urine escape through the torn capsule into the perirenal space. This forms a retroperitoneal mass. If bleeding continues the mass will increase in size until hemorrhage is stopped by the counter pressure. The extravasated blood and urine may be absorbed without becoming infected. If it becomes infected there will be increased pain, enlargement of the tumor, rise in temperature and leukocytosis. Where the peritoneum is torn the blood and extravasated urine will pour into the peritoneal cavity. Fatal hemorrhage may rapidly follow a rupture of the renal vessel. The entrance of urine into the peritoneal cavity invariably sets up a peritonitis. The lines of rupture usually radiate from the hilum roughly transverse to the long axis of the kidney, following the fetal lobulations.

Fig. 1. Case 1. Normal pyelogram of the right side. Subcapsular rupture of lower and middle calyx on left side.

Fig. 2. Case 1. Fifty-two days later, normal pyelogram of right side. Left upper calyx normal. Lower and middle calyces obliterated.

DIAGNOSIS

A careful history is of first importance and should be obtained if possible. The possibility of kidney rupture should be thought of in all cases where severe force has been applied to the loin.

Signs and Symptoms. Shock may be of momentary duration or may continue; collapse may appear hours or days following a period of comparative comfort due to severe secondary hemorrhage. Hematuria is the most constant of all signs, though not infallible as no blood may reach the bladder because of the presence of a clot or severance of the ureter. Mass in the loin is a common sign, varying in size, extent, and rapidity of accumulation, on the location and extent of the injury. If the pelvic cavity is torn the mass will

FIG. 3. Case II. Normal right pyelogram. Dilatation, narrowing and irregularity of upper and lower calyces of left side. Total rupture left kidney. Immediate nephrectomy.

consist of blood and urine. If the parenchyma alone is torn there will be only extravasation of blood. Pain and tenderness are usually present over the affected side, both front and back. Muscle rigidity is often unilateral but may be present in the abdominal muscles on both sides. The leg on the affected side is sometimes drawn up. If there is marked evidence of peritoneal irritation, as in one of our cases, the abdominal signs may mask the picture of the urinary tract lesion. The temperature is rarely much elevated at the beginning but may rise to 101–103° F. after a few days and continue during the period in which the extravasated blood and urine are being absorbed.

Roentgen Findings. A roentgenogram of the urinary tract may reveal a fracture of the lower ribs adjacent to the kidney or may show a fracture of the transverse processes of the vertebrae. If there is a large retroperitoneal mass of extravasated blood and urine, the kidney and psoas shadow may be obscured on the affected side. At best this is only presumptive evidence.

Retrograde Pyelography. One author (Beach) states, "The valuable information obtained and the brief interval required to do a pyelogram more than compensate for the inconvenience or possible hazard to the patient," and along with many authors he recommends pyelography just as soon as the patient's condition will permit. On the other hand, Wesson cautions that, "Instrumentation is to be avoided when possible because of the danger of infection." There are many case reports in which pyelograms were made demonstrating rupture of the kidney. In most of these cases immediate nephrectomy was performed so that the element of infection was of less consequence than if the patient had been treated conservatively. As there is the hazard of infection, plus the added shock of instrumentation, retrograde pyelog-

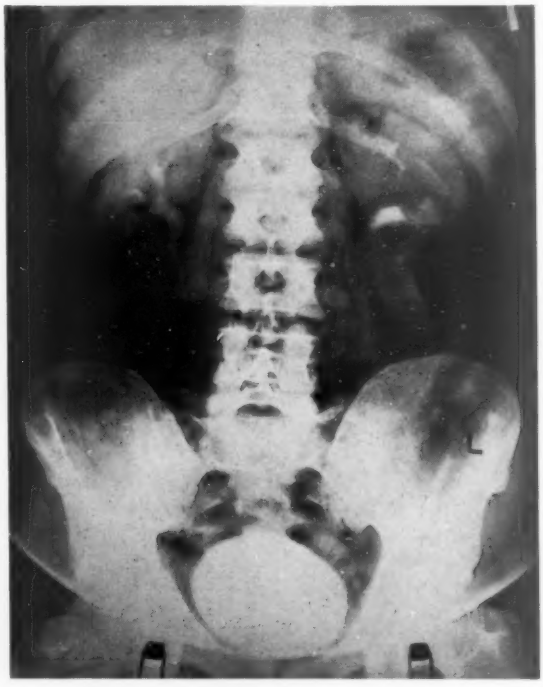

FIG. 4. Case III. Ten days after accident. Normal right pyelogram. Left kidney increased in size. Pelvis and calyces almost obliterated. Rupture of parenchyma.

raphy should be avoided in these cases if possible.

Excretory Urography. Uroselectan, introduced in November, 1929, by von Lichtenberg and Swick, was the first satisfactory contrast medium to be used for excretory urography. Bronner and Schüller, in 1930, made the first announcement of their work with abrodil. This drug was introduced into America as skiodan. Swick, in 1933, introduced iodohippuric acid which could be given either intravenously or by mouth. This drug is now sold as hippuran. All are now conveniently dispensed in sterile ampules, greatly facilitating their use. In our clinics we have used all of these preparations successfully, with no serious reactions. The oral administration of hippuran did not give us as good shadows as the other preparations and its use has been discontinued. Recently we have been using diodrast, as it has proved to be non-toxic, produces very little reaction of the vein, and gives satisfactory urograms in a brief time. No special virtue is acribed to this particular preparation but there is considerable advantage in using a medium with whose normal excretion time one is familiar in order that abnormal variations may be better estimated.

Fig. 5. Case III. Two months later. Right side normal, left now has appearance of normal kidney.

Fig. 6. Case IV. Day after admission. Left pyelogram normal. Right, complete lack of function.

Fillis, in 1931, reported a rupture of the kidney demonstrated by excretory urography. Previous to this there were some reports in the foreign literature of such cases. Subsequently there have been several cases reported in the American medical literature. There must be many unreported cases as the frequency of the accident is high and the use of excretory urography is now universal.

Excretory urography affords a safe, rapid and very accurate method of diagnosis of traumatic lesions of the urinary tract. In all such cases it is the method of choice and in children is often the only method practicable. There is no increased hazard of infection and practically no reports of untoward reactions.

The intravenous injection of diodrast

FIG. 7. Case IV. Forty-four days after accident. Right side apparently functionless. Left side normal.

can be made by anyone familiar with the technique of intravenous medication. The injection is given with the patient supine on the roentgenographic table. As soon as the injection is given, pressure is applied over the lower ureters and the head of the table is lowered 5 degrees. The first roentgenogram is made in five minutes, using 100 ma. technique and a Potter-Bucky diaphragm. It is imperative to use a film large enough to include the entire urinary tract. Further roentgenograms are made at intervals, with pressure and after release of pressure over the ureters, until the entire tract is visualized. In some cases it has been necessary to wait one or two hours to have sufficient concentration in the kidney to give an image. One of the greatest advantages has been the visualization of not only the injured but the normal kidney, thus giving a rough index of the function of each kidney. The ureters are usually visualized and the bladder always. If there is injury to the ureters or bladder this may usually be ascertained by this single procedure.

One usually assumes that before the trauma the kidneys were both normal unless there is a history to the contrary. Such an assumption is not always tenable. The diagnosis in some cases is not conclusive, as there may be sufficient injury to the kidney to entirely stop its function. This may be temporary or permanent. One such case will be reported. One must assume that either the kidney was so badly damaged as to stop its function or that a clot in the pelvis caused sufficient back pressure to prevent function.

RUPTURE OF THE URETER

Most ruptures of the ureter occur as an accident in the course of lower abdominal surgery and are not within the scope of this discussion.

Falls and application of external force may cause rupture of the ureter. Legueu, in his report of 3 cases, concludes that torsion of the body is the only plausible explanation of such ruptures.

FIG. 8. Case V. Left side normal. Right side shows extravasation of medium into parenchyma of lower pole. Rupture of lower calyx.

Fig. 9. Case v. Seventy-two days later. Both sides normal in appearance. Complete healing of rupture of right lower pole.

Fig. 10. Case vi. Ten minutes after injection, shows normal left pyelogram, right shows no function.

Fig. 11. Case vi. Forty-five minutes after injection. Left side normal, right side shows hydronephrosis with displacement upward of renal pelvis and calyces. Rupture of the lower calyx.

Fig. 12. Case vi. Fifteen months later. Good function of both kidneys. The right renal pelvis is slightly larger than the left.

Cases of rupture of the ureter are reported in which the ureter was apparently cut when the ilium was fractured.

Le Comte, in his report of the case of gunshot wound of the ureter, in our series, gives a full review of the literature. He states that, "Stab and gunshot wounds of the ureter are so rare as to be almost curiosities even in time of active warfare." Ureteral ruptures are classified as total when all of the coats are injured and as partial when one layer is involved. They are said to be complete when the entire circumference is cut and as incomplete when the injury is tangential. When the lumen of the ureter is opened, urine is extravasated into the surrounding tissues. If the tract of the penetrating object remains patent, the urine may escape into the peritoneum or onto the skin. If the ureter is ruptured without an opening to the exterior or into the peritoneal cavity, the extravasated urine will collect as a lumbar mass. This mass is slow in accumulation but progressively enlarges.

Retrograde pyelography may be misleading, as the contrast medium will diffuse over the loin, and a ruptured kidney may be suspected.

No reports of cases were found in the literature in which excretory urography was used in diagnosis. In our case of rupture of the ureter, it was used after drainage of the lumbar mass, and shows a normal kidney pelvis with rupture of the ureter.

Excretory urography furnishes the ideal method of diagnosis of rupture of the ureter, especially if used before too large a mass of extravasated urine has accumulated. A lesion of the kidney could thus easily be excluded and at the same time a lesion of the ureter demonstrated.

RUPTURE OF THE URINARY BLADDER

The subject of rupture of the bladder is mostly in the field of the urological surgeon.

It is caused directly by increased hydrostatic pressure and by wounds produced by the passage of some foreign object. It must be considered and ruled out in cases of fracture of the pelvis or following direct violence to the lower abdomen. Excretory cystography supplies a satisfactory method of diagnosis without any of the hazard incidental to retrograde cystoscopy.

We have had only one case of injury to the bladder demonstrated by excretory urography. In that case the bladder was not sufficiently damaged to cause extravasation of urine.

Excretory urography has done much to simplify diagnosis and improve prognosis of traumatic lesions of the upper urinary tract. By virtue of it more cases can now be treated expectantly with reasonable assurance of complete recovery, which formerly would have been subjected to at least an exploratory lumbar incision and possibly nephrectomy.

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ROENTGEN TECHNIQUE FOR THE INTERNAL FIXATION OF FRACTURES OF THE FEMORAL NECK

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THE high mortality associated with fractures of the femoral neck in the aged led Wescott[2] to the use of the Smith-Petersen nail for the purpose of holding the fragments in position until union had taken place. The surgical details of this procedure have been described elsewhere. It is the purpose of this paper to describe the roentgen studies that are used in conjunction with this method. The roentgen ray plays an important part because (1) it is used before the operation to determine the femoral angles and exact length of the nail to be used at operation and (2) the nail is driven through the distal fragment and into the neck of the femur and the proximal fragment under roentgen control. The roentgenologist plays as important a part as the surgeon and more time is occupied during the operation by the roentgen procedures than is taken by the surgeon.

FIG. 1. Showing ordinary spike passing through femoral neck of a cadaver.

EXPERIMENTAL WORK

It was necessary to work out a simple method by which the angles of the femur could be estimated. In working with cadavers the following observations were made: The angle of the neck with the shaft as seen in the true anteroposterior view can be measured directly from the film. The forward angle (angle of anterior torsion or anteversion, or angle of direction) is more difficult to calculate. With the condyles level with the table top the roentgen ray is allowed to traverse the hip at angles varying from 5 to 30°. The proper angle is the one in which the head is accurately superimposed by the entire neck. By then rotating the femur internally until the condyles form the estimated angle with the table top, the neck of the femur is thrown flat, thus correcting the forward angle. The angle of the neck having been previously determined, a nail could then be driven horizontally and made to pass directly through the neck of the femur. This test was made on a number of cadavers and it was found that correct estimation was not difficult. Roentgen examinations during and after this procedure showed the course of the nail through the neck of the femur (Fig. 1).

PREOPERATIVE EXAMINATIONS

It is necessary to determine preoperatively the following: (1) the forward angle, and (2) the length of nail to be used. The necessary examinations are made in the patient's room on the day before operation. All examinations are made on the normal hip.

The forward angle is determined as follows: The condyles of the femur are placed in the neutral position, neither internally nor externally rotated. Exposures are then made obliquely through the normal hip with the cassette always at right angles to the central ray. The angles at which the exposures are made are varied from 5 to 30°. The roentgenogram showing the head superimposed on the neck is the one which designates the proper angle. It has been found that a curved cassette will not give the information that can be obtained from this procedure.

The length of the nail is determined as follows: The condyles of the femur are internally rotated the required number of degrees to flatten the neck. A cassette is placed immediately beneath the normal hip. A measuring rod graduated in inches is strapped opposite the center of the greater trochanter in line with the shaft. The measuring rod being the same distance from the cassette as the femoral neck is therefore equally magnified on the plate. On the resultant roentgenogram the distance is measured from the middle of the head to a point 1 inch below the vastus internus line. This distance is superimposed on the shadow of the measuring rod and the exact necessary length of the nail can be read. The examinations are made with the patient in bed and cause no discomfort.

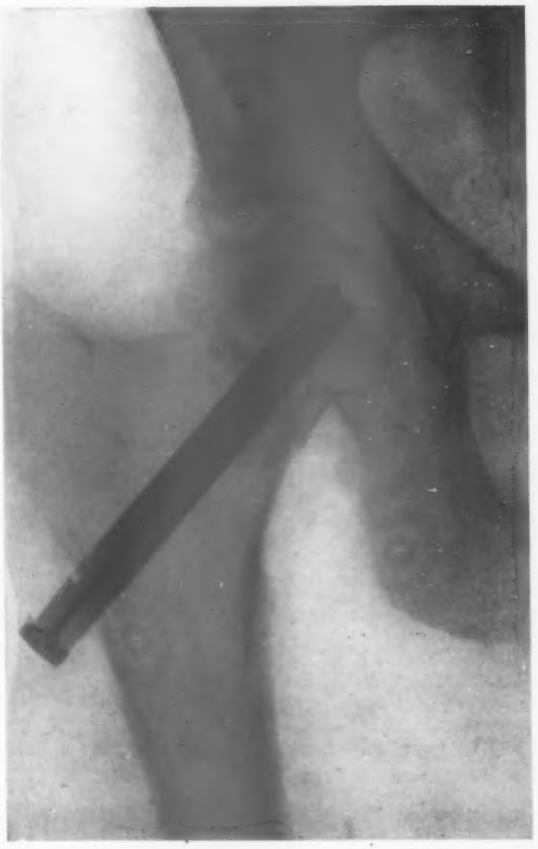

Fig. 2. The Smith-Petersen nail in position at the end of four months, with the fracture line partially obliterated by new bone formation.

Introduction of the Nail

Wescott uses the Smith-Petersen three flanged nail.[1] This is milled from a solid piece of stainless steel. The nails can be kept in assorted lengths or can be made upon short notice to suit the individual case. The forward angle having been determined, and the nail having been made the correct length to transfix the fragments, the patient is now ready for operation. A general anesthetic is necessary and avertin is the anesthetic of choice, since it gives a prolonged effect which can be supplemented by nitrous oxide without shock to the patient. A tunnel, or flat Potter-Bucky diaphragm, is placed beneath the fractured hip and a portable roentgen unit is placed near the operating table so that stereoscopic films may be made without moving the patient or interfering with the operative field. The fragments are reduced by the surgeon and checked by stereoscopic films. These have to be read while still wet and a stereoscopic viewbox is placed adjacent to the operating room for this purpose. The plates made to determine the success of the reduction are taken with the femur rotated inward, the lower condyles being internally rotated sufficiently to flatten the neck. As soon as the fragments have been satisfactorily reduced, the angle of the neck is determined from these films by a protractor made especially for this purpose. The surgeon then makes a small incision, 2½ to 3 inches in length, over and below the greater trochanter in line with

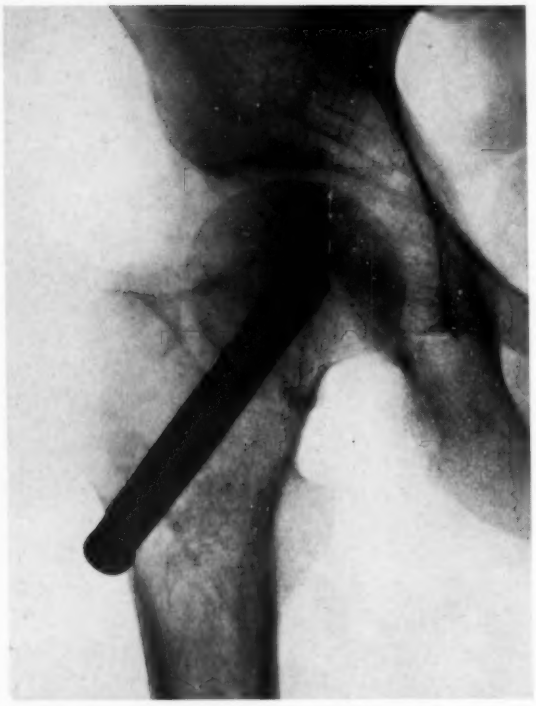

FIG. 3. Smith-Petersen nail in position seven weeks after reduction and operation.

the shaft, and the nail is started, usually about 1 inch below the vastus internus line. A special bone protractor is used by the surgeon to obtain the exact degree of angulation that was measured from the film. When the nail has been driven well into the distal fragment, stereoscopic films are made to see if the nail is still aligned and going at the proper angles. The nail is kept flat with the table top. It sometimes happens that the nail is started at a poor angle. In such a case the nail is partially withdrawn and the angle changed as indicated by the second roentgen examination. When two-thirds of the nail has been driven in, stereoscopic films are again made. By this time the end of the nail has usually passed the site of injury. If the position of the nail is satisfactory, it is driven entirely in by means of a nail carrier, and the fragments impacted. Stereoscopic films are made for comparison with films of a later date (Figs. 2 and 3).

The responsibility of placing the condyles at the proper degree of internal rotation rests chiefly on the roentgenologist, who is usually more accustomed to estimating angles than the surgeon. If the condyles are internally rotated the proper amount, the neck is flat and the forward angle does not enter into the operation.

The surgeon can frequently tell if the nail is going in the proper channel by the resistance, sensation, sound, etc., that is experienced on driving the nail. If the angles have been correctly estimated and there is good reduction, this can be done in a great many cases. In such instances, roentgen examinations are necessary only following reduction and after the complete insertion of the nail.

COMMENT

For many years attempts have been made to fix transcervical fractures of the femur with various types of nails, screws, wires, skewers and bone grafts. Those instruments of fixation inserted by exposing the fragments were more or less successful. The operation in itself is too severe for the average aged individual, however. Except by the open operation the old method of inserting the instrument of fixation has, except in a few instances, proved disappointing, because in the majority of these cases the instrument of fixation was found to transfix the soft tissues rather than the fragments. Reduction of the femur and application of the Whitman cast have proved that the fracture may be reduced well enough to produce bony union without an open operation. The long period of fixation, however, proves too exacting for the elderly individual with a fracture of this type. The internal fixation of these fractures and the free use of the hip joint following fixation, without use of cast or splint, would tend to produce early union. By roentgenographically determining the angles of the femoral neck, as previously described, it is possible to eliminate (1) the operation into the joint, (2) exposing the fractured surfaces, and (3) fixation in plaster following reduction. While this method is not difficult, it cannot be simpli-

fied beyond a certain extent because accurate determination of the angles of the femoral neck requires accurate observation and some practice is necessary in reading the wet stereoscopic films in order that the nail may be accurately guided.

The time consumed during the operation is in great part due to the time it takes to develop the plates. Ten minutes is the minimum time that is necessary for processing the plates and returning them to the operating room. As soon as the plates are returned from the dark room, they are placed in the stereoscope. The roentgenologist and the surgeon are able to study them and consult before the operation is carried further. It has been found by practice that the surgeon can view the plates stereoscopically without gown or gloves becoming contaminated.

For those who see a large number of fractured hips the results obtained from this method are striking. The operation is performed as soon as the patient has recovered from shock and the angles have been determined. This is usually within twenty-four to forty-eight hours after the patient has been admitted to the hospital. The injured leg is kept in traction before operation and overriding is seldom found when the patient is taken to the operating room. Avertin gives a prolonged anesthesia and is preferred by Wescott.[3] This gives plenty of time for prolongation of the operation and films may be studied in a leisurely manner. Avertin is often supplemented by nitrous oxide during the active operative procedure. After the nail has been placed in the proper position and the wound closed, the leg is rotated and flexed at the hip to see if there is complete motion. There is very little discomfort after reaction from the anesthesia. The skin incision is the only point of discomfort. A back rest is given as soon as the patient recovers from the avertin and the use of a wheel chair is allowed on the following day. Crutches are given on the 3rd or 4th day, and as soon as the patient becomes accustomed to these he is allowed to leave the hospital.

The ultimate test of these procedures will be to determine what percentage of good unions is obtained. As Whitman[4] states, "Repair of a medial fracture requires many months for its accomplishment." Non-union has not occurred in any case at the time of this writing. The nail has not been found to interfere with healing but it is withdrawn as soon as the fracture line has been completely obliterated by formation of new bone, for it is a foreign body which might produce harmful results at a later date.

CONCLUSIONS

A method has been described for estimation of the angles of the femoral neck. These angles must be accurately determined before the Wescott method of fixation can be performed. Preoperative estimations of the angles are made on the normal hip. A steel nail is introduced and its course guided by stereoscopic roentgenograms. The short period of hospitalization, the immediate comfort that the operation brings the patient, and the low mortality rate give this operation an advantage over other procedures for treatment of this condition. Satisfactory results depend greatly on close cooperation and understanding between the surgeon and the roentgenologist.

I wish to express my appreciation to Dr. Hayward H. Wescott for assistance in correlating the portion of this paper dealing with the operative procedures. I also wish to express appreciation for the cooperation extended by the Anatomical and Roentgenological Departments of the University of Virginia.

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MODIFICATION OF RADIOSENSITIVITY BY MEANS OF READILY PENETRATING ACIDS AND BASES*

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MANY investigations have dealt with factors which influence the sensitivity of cells to roentgen rays and gamma rays, but the results reported are often contradictory.** This confusion may be wholly or partly due to the fact that many of the factors studied—such as rate of growth, rate of metabolism, phase of mitosis—are very complex, each influencing or being influenced by a number of simpler factors, any one of which may or may not influence the radiosensitivity. This suggests the investigation of the effects of simpler factors.

One relatively simple factor which may vary widely in any individual cell is the intracellular concentration of carbon dioxide. In the experiments to be reported here numerous measurements have been made of the relative radiosensitivity of certain cells when irradiated in equilibrium with various concentrations of this penetrating substance. Radiosensitivity has been found to vary in a characteristic fashion with the concentration of carbon dioxide present during irradiation. In order to test the hypothesis that the action of the carbon dioxide was due to changes in intracellular acidity, further experiments have been performed with another penetrating acid, hydrogen sulphide, and with the penetrating base ammonia.

PROCEDURE

The source of roentgen rays was a self-rectifying gas tube essentially similar to the one described by Wyckoff and Lagsdin.[5] The tube was equipped with a copper target, and the radiation consisted mostly of the Kα and Kβ lines of this element (wave lengths respectively 1.54 and 1.39 Ångströms). This tube and its accessories were designed and built by Dr. A. L. Patterson.

The biological test object chiefly used was the germinating unicellular spore of the fern *Pteris longifolia*. This material is very advantageous in work of this kind because of the ease with which one may deal with large numbers of individuals. A secondary and less convenient test object was *Paramecium caudatum*.

Since the structure and normal behavior of the fern spore have been described elsewhere[6] at some length, only a brief description will be given here. The cells are rounded tetrahedrons averaging 46 micra in diameter. The spore wall is 4 micra thick and bears a distinct Y-shaped set of sutures. After the average spore has been moistened about four days in a suitable mineral nutrient solution* at 25° C., the wall cracks along these sutures and the contents protrude. On the fifth day chlorophyll can be detected in the protruding portion of the cell, and on the sixth the elongating protruding filament undergoes the first cell division. This division is easy to detect because the cell distal to the cracked spore wall receives most of the chlorophyll.

In irradiated spores this normal succession of germination phenomena is retarded or inhibited. The degree of retardation or the stage at which the activities come to a halt depends upon the dose of radiation. In the present work, the specific biological response studied was complete inhibition of the first cell division. The degree of the response to any given treatment was indicated by the percentage of cells which divided.

Spores to be irradiated were prepared in lots of about 300. Each lot was spread in a single layer over a piece of smooth filter paper which

** The literature concerning this has been reviewed by Packard.[3]

* The composition of the medium used was:

NH_4NO_3	0.5 gram
$MgSO_4 \cdot 7H_2O$	0.2 gram
KH_2PO_4	0.2 gram
$CaCl_2 \cdot 6\,H_2O$	0.1 gram
$FeCl_3$	0.01 gram
Distilled water	1 liter

In the previous description [6] of this solution, NH_4OH was erroneously written for NH_4NO_3.

* Read at the Thirty-fifth Annual Meeting, American Roentgen Ray Society, Pittsburgh, Pa., Sept. 25–28, 1934.
† National Research Fellow in the Biological Sciences.

was 2 mm. wide and 4 mm. long and moistened with mineral nutrient solution. All lots to be used in the same experiment were placed in a petri dish on a thick moist pad of filter paper, and the dish was then placed in a box and illuminated for twenty hours by the light from a white-frosted 7.5 watt lamp at a distance of 20 cm. (This preliminary period of moistening was of course necessary to get the cells wet enough to allow the penetration of the carbon dioxide or other substance used. The lamp was necessary because the spores do not absorb water satisfactorily in the dark.)

During irradiation the spores were contained in the apparatus shown diagrammatically in Figure 1. The three chambers *A* were milled in a solid piece of brass *B*. Each chamber was 12 mm. in depth and 7 c.c. in volume, had two openings *C* provided with needle valves, and was lined with paraffin to avoid possible toxicity of the brass.

When the effect of carbon dioxide was to be tested the procedure was as follows: Three lots of 300 spores each were placed in each chamber on a pad of moistened filter paper. Care was taken that all nine lots lay just inside the dotted circle. This made it possible, by rotating the entire apparatus during irradiation, to insure the delivery of exactly the same dose of radiation to the lots in the various chambers. Care was also taken that the lots were placed exactly the same in all three chambers, thus making sure that the intensity of scattered radiation received by the spores in the various chambers would be the same.

The chambers were covered with cellophane about 0.001 inch thick, which had negligible stopping power for the soft roentgen rays used. The seal between brass and cellophane was made with vaseline. The air in one of the chambers was replaced with any desired mixture of carbon dioxide and air by opening the two valves at *C*, allowing about 300 c.c. of the gas mixture to stream slowly from the mixing vessel through the irradiation chamber, and then closing the valves. The air in a second chamber was similarly replaced with another mixture of different carbon dioxide content. Air was left in the third chamber. The entire apparatus was allowed to stand twenty minutes to let the cells come to equilibrium with the various concentrations of carbon dioxide. The gas in each chamber was then renewed by a second streaming with the proper mixture of air and carbon dioxide, and irradiation followed immediately. The duration of irradiation was fifteen minutes,* all lots being given the same dose. Immediately after irradiation, all lots were removed from the gas chambers and placed on a moist pad of filter paper in air.

The procedure during irradiation with hydrogen sulphide was similar to that with carbon dioxide. When ammonia was used, however, the high solubility of this substance made it feasible to put the hydroxide directly in the culture solution used to moisten the filter paper. The apparatus of Figure 1 was then used only as a set of moist chambers rather than as a set of gas chambers.

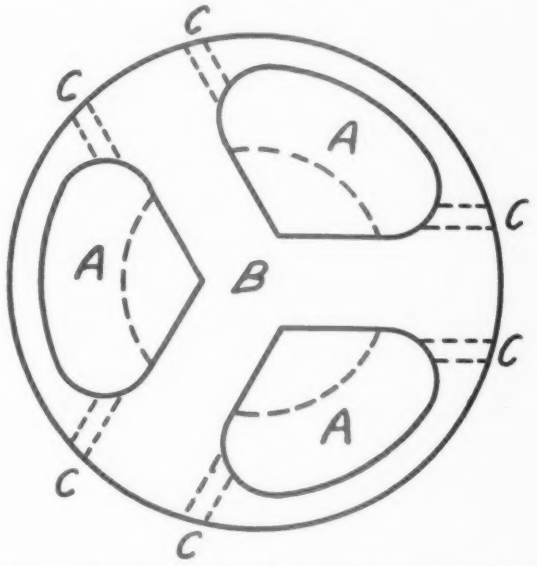

Fig. 1. Set of gas chambers which contained the biological material during irradiation. See text for description.

After irradiation each lot of spores was washed from its 2×4 mm. piece of filter paper and scattered over one measuring about 12×20 mm. All lots of a given experiment were then placed on a single pad of filter paper in a large petri dish and set in a north window to germinate if they could. At the end of ten days all spores were examined microscopically and classified as divided or undivided.

When *Paramecium* was used, the organisms were placed in small glass dishes in a layer of culture medium (hay infusion) about 0.5 mm.

* The output of the tube in roentgens is not known, since the ionization chamber was designed for relative, rather than absolute, measurements. However, when the results of several preliminary experiments on the killing of *Drosophila* eggs are compared with the data of Packard[3] and of Henshaw and Henshaw[2] it is evident that the number of roentgens per minute was in the neighborhood of 2,000.

deep and the dishes were then placed in the gas chambers for irradiation. After an irradiation of forty-five minutes, individual animals were pipetted from each irradiated lot and cultured overnight in watch glasses containing about 1 c.c. of hay infusion. The watch glasses were kept in moist chambers, in which were also placed similarly isolated non-irradiated control animals. On the day following irradiation the number of descendants of each isolated cell was recorded.

RESULTS

Experiments with the Fern Spore

Carbon Dioxide. Table 1 illustrates the manner in which the radiosensitivity of the fern spore varies with the concentration of carbon dioxide in the gas chambers. The three experiments summarized in this table were all set up on the same day, with the roentgen tube operating continuously, and all the spores were set to germinate in the same dish.

TABLE I

VARIATION OF RADIOSENSITIVITY OF THE FERN SPORE WITH THE PERCENTAGE OF CARBON DIOXIDE IN THE ATMOSPHERE DURING IRRADIATION. (TEMPERATURE 25° C.)

For explanation see text.

Experiment	Concentration CO_2		Percentage Division	Relative Radiosensitivity
	Percentage in Atmosphere	Molality in Solution		
100a	0	0	28	1.00
	10	0.003	20	1.10
	20	0.006	7	1.50
100b	0	0	31	1.00
	30	0.009	19	1.20
	50	0.015	22	1.16
100c	0	0	26	1.00
	75	0.023	36	0.87
	100	0.031	59	0.63

In Experiment 100a, 28 per cent of the spores irradiated in air were able to divide, while of those irradiated for the same length of time in 10 per cent carbon dioxide only 20 per cent were able to divide. It is hence plain that the radiosensitivity was greater in 10 per cent carbon dioxide than in air. Moreover, since only 7 per cent of the spores irradiated in 20 per cent carbon dioxide were able to divide, it is evident that the radiosensitivity in this concentration was greater than in air or in 10 per cent carbon dioxide.

A similar consideration of Experiment 100b makes it clear that the radiosensitivity of the spores is greater in both 30 and 50 per cent carbon dioxide than in air. Moreover, since the percentages of division accomplished by the lots irradiated in air in Experiments 100a and 100b were very nearly the same (28 and 31 per cent respectively) it is evident that the radiosensitivity in 20 per cent carbon dioxide was markedly greater than in 10, 30, or 50 per cent.

The percentages of division obtained in Experiment 100c show that the radiosensitivity in 75 per cent carbon dioxide is not greater but markedly less than in air while the same is true, but in far greater degree, for the radiosensitivity in 100 per cent carbon dioxide.

Numerical values of the radiosensitivity in the various concentrations of carbon dioxide have been obtained as follows. The course of the survival curve for spores irradiated in air is shown in Figure 2. The

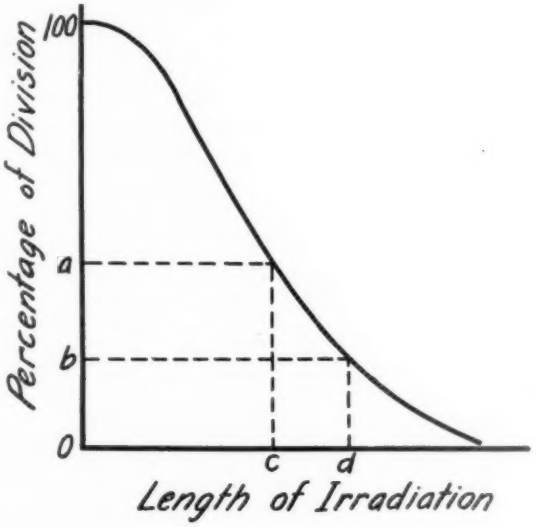

FIG. 2. Survival curve of the fern spore, cell division being the criterion of survival. For discussion see text.

to divide after irradiation, the abscissas the lengths of the doses. Let us consider two lots of spores which are given simultaneously a dose of c minutes. The first lot, irradiated in air, shows a percentage a of division; the second, irradiated in m per cent of carbon dioxide, shows a percentage b. Now it is evident from the figure that, if ordinates are the percentages of cells able the second lot had been irradiated in air instead of m per cent carbon dioxide, it would have been necessary to increase the irradiation from c minutes to d minutes in order to reduce division to b per cent. Hence the effectiveness of irradiation in air is to the effectiveness in m per cent carbon dioxide as c is to d. Moreover, since radiosensitivity of the cells is merely another expression for effectiveness of the irradiation,

$$\frac{R_m}{R_0} = \frac{d}{c}$$

where R_m and R_0 are radiosensitivity in m per cent carbon dioxide and in air respectively.

When R_0 is arbitrarily set equal to unity and the formula above is applied to the data in the fourth column of Table I, the numbers in the last column are obtained as values of the relative radiosensitivity in the various concentrations of carbon dioxide. These values are plotted in Figure 3(*a*). The resulting curve is characterized chiefly by the sharp maximum in radiosensitivity at 20 per cent carbon dioxide. The course of this curve has been verified by another experiment dealing with all, and several others dealing with various portions of, the range of carbon dioxide concentration used in Experiment 100.

Ammonia. Figure 3(*b*) summarizes the results obtained in the experiments with ammonia. Since the lower concentrations of carbon dioxide increased the radiosensitivity, it is to be expected that, if the carbon dioxide operates by changing acidity, low concentrations of ammonia should decrease it.* Figure 3(*b*) shows that such

* It would of course be possible for a minimum or an abrupt flattening of the radiosensitivity curve to occur at that particular degree of acidity present ordinarily in the cell. However, the probability of this is small.

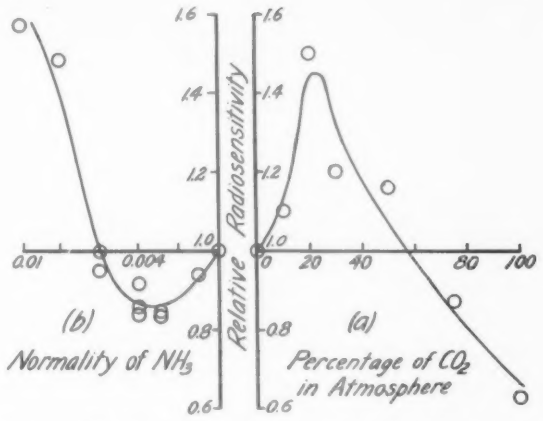

FIG. 3. Variation of radiosensitivity of the fern spore with concentration of penetrating acid and base. (*a*) Carbon dioxide. (*b*) Ammonia. (Note that (*a*) and (*b*) produce an apparently continuous curve if the zero points of the two abscissas are brought together.)

a decrease actually occurs. The curve then passes through a minimum between 0.003 and 0.004 normal ammonia and rises sharply, so that at 0.006 normal ammonia the radiosensitivity is the same as it is in

TABLE II

VARIATION OF THE RADIOSENSITIVITY OF THE FERN SPORE WITH THE NORMALITY OF AMMONIA IN THE CULTURE SOLUTION DURING IRRADIATION. (TEMPERATURE 25° C.)

For explanations see text.

Experiment	Normality of Ammonia	Number of Spores Classified	Percentage Division	Relative Radiosensitivity
81	0	566	24	1.00
	0.004	679	34	0.86
83	0	621	75	1.00
	0.001	638	77	0.94
	0.003	616	82	0.84
	0.010	566	50	1.57
88	0	1104	58	1.00
	0.003	1279	63	0.92
	0.006	1112	58	1.00
91	0	752	28	1.00
	0.003	901	39	0.85
	0.006	798	32	0.95
92	0	858	28	1.00
	0.004	830	40	0.84
	0.008	558	5	1.48

the absence of ammonia and at 0.008 normal nearly one and a half times as great. The data upon which this curve is based are collected in Table II. The method of converting percentages of division to numerical values of radiosensitivity was the same as already described for the carbon dioxide experiments.

Hydrogen Sulphide. The results of the experiments with hydrogen sulphide are presented in Figure 4 and Table III. In Figure 4 it will be noted that the effect of hydrogen sulphide upon radiosensitivity is very similar to that of carbon dioxide: The curve first ascends to an abrupt maximum and then descends to radiosensitivity values of less than unity.

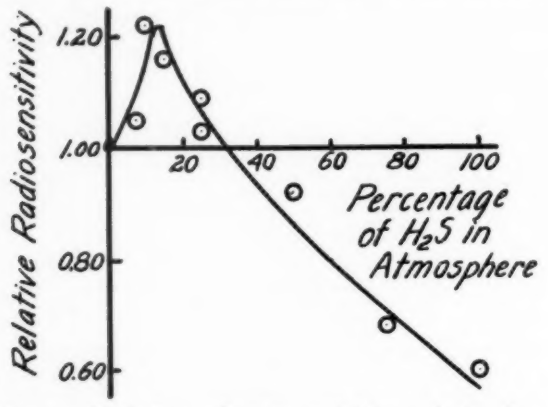

FIG. 4. Variation of radiosensitivity of the fern spore with concentration of hydrogen sulphide. (Note the similarity between the shape of this curve and that for carbon dioxide, Fig. 3, *a*.)

Accessory Experiments. Numerous control experiments were carried out to detect possible effects of carbon dioxide, hydrogen sulphide, and ammonia without the irradiation. None of these substances, in the concentrations used to modify radiosensitivity, affected cell division or any other activity of the cell in any detectable way. This was true even when retardation of division, which is a more delicate criterion than total inhibition, was used for a basis of comparison. It also held when the substances were applied to the cells two or three times as long as when used upon irradiated lots.

In one experiment spores were irradiated in air and exposed immediately afterward to 25 per cent carbon dioxide. Even when the exposure to carbon dioxide was as long as 4.5 hours, the radiosensitivity of the spores remained exactly the same as those kept in air throughout. It is hence evident that the modifications of radiosensitivity described above are due to the modified state of the cell during the actual absorption of the radiation or at most for only a few minutes afterward.

The possibility that part of the effects noted with the higher concentrations of carbon dioxide and hydrogen sulphide might be due to oxygen deficiency was checked by an experiment with nitrogen.* This gas, when used as were the carbon dioxide and the hydrogen sulphide, had no detectable effect upon radiosensitivity.

TABLE III

VARIATION OF THE RADIOSENSITIVITY OF THE FERN SPORE WITH THE CONCENTRATION OF HYDROGEN SULPHIDE IN THE CULTURE SOLUTION DURING IRRADIATION. (TEMPERATURE 25° C.)

For explanation see text.

Experiment	Molality of Hydrogen Sulphide	Number of Spores Classified	Percentage Division	Relative Radiosensitivity
89	0	1074	41	1.00
	0.010	938	27	1.22
	0.025	1003	36	1.09
101a	0	713	39	1.00
	0.025	602	38	1.03
	0.050	383	48	0.92
101b	0	525	38	1.00
	0.075	353	64	0.68
	0.100	378	67	0.60
102	0	691	30	1.00
	0.0075	688	28	1.05
	0.015	795	20	1.16

Experiments with Paramecium. The work with *Paramecium* has so far dealt with only two concentrations of carbon dioxide—25 and 50 per cent. No satisfactory numerical estimates of relative radiosensitivity, as

* I am indebted to Mr. M. G. Larrabee for carrying out this experiment.

were made in the case of the fern spore, can be made with the present data. However, it can be seen from Table IV that both 25 and 50 per cent carbon dioxide modify the radiosensitivity of this organism (retardation of cell division as criterion) to a readily detectable degree. It is hence plain that modification of radiosensitivity by carbon dioxide is not a phenomenon peculiar to the fern spore. Whether or not the radiosensitivity curve of *Paramecium* is similar in shape to that of the fern spore remains to be determined.

TABLE IV

MODIFICATION OF THE RADIOSENSITIVITY OF PARAMECIUM BY CARBON DIOXIDE

For explanation see text.

Experiment	Hours Between Irradiation and Classification	Criterion	Percentage of CO_2	Number of Individuals	Percentage Accomplishment
8	19	2 cells or more	25	34	74
			0	32	100
	48	More than 8 cells	25	34	35
			0	32	66
9	18	2 cells or more	50	39	64
			0	40	97
	22	4 cells or more	50	39	5
			0	40	40
10	42	2 cells or more	25	60	33
			0	58	71
	42	Retention of motility	25	60	77
			0	58	91

Neither 25 nor 50 per cent carbon dioxide, without irradiation, had any effect upon the rate of division. All non-irradiated lots of animals divided at least twice and usually three times in twenty-four hours.

DISCUSSION

When the first experiments with carbon dioxide demonstrated significant modification of radiosensitivity, it immediately became desirable to choose some hypothesis concerning the mode of action of this substance. Were the observed effects due to changes in intracellular acidity, to carbon dioxide anesthesia, or to some specific action of the carbon dioxide molecule? The first of these alternatives seemed most amenable to experimental tests, and the subsequent results yielded two strong substantiating facts: First, the effects of the two acids, carbon dioxide and hydrogen sulphide, vary with concentration in the same characteristic fashion. Second, the effect of the ammonia in the lower concentrations is opposite to that of the acids in the lower concentrations.

The question now arises: How does change in intracellular acidity bring about modification of radiosensitivity? It is of particular interest in this connection that proteins have been found (Wels and Thiele;[4] Fernau and Spiegel-Adolf[1]) to be much more easily flocculated by roentgen rays and gamma rays when irradiated at their isoelectric points than when irradiated in a more acid or more alkaline medium. This fact makes it possible tentatively to explain the maximum in the radiosensitivity-acidity curve of the fern spore as follows: The extent of flocculation of a certain protein (or proteins) is the quantity on which depends the severity with which any given function of the cell (e.g., cell division) is impaired. In the fern spore, this protein is normally in a medium slightly alkaline to its isoelectric point. Addition of small amounts of penetrating acid (carbon dioxide or hydrogen sulphide) shifts the acidity toward the isoelectric point and the radiosensitivity increases up to this point. Still further additions increase the acidity beyond the isoelectric point and the radiosensitivity accordingly diminishes. If ammonia be added to the normally slightly alkaline medium of the hypothetical protein, the reaction of the medium would be shifted farther away from the isoelectric point (in the alkaline direction) and the radiosensitivity should decrease. This decrease actually occurs (Fig. 3, *b*) with concentrations of ammonia up to 0.003 N. However, at this point a minimum appears in the curve and the

radiosensitivity increases rapidly with still further increases in ammonia concentration. This minimum may represent the point at which a toxic action of the ammonia becomes effective upon cells injured by the radiation, for although absolutely no toxic effect upon non-irradiated spores could be detected with the highest concentration shown in Figure 3 (0.01 N) yet a doubling of this concentration brought about clearcut injury to these otherwise untreated cells.

Whether or not the theory outlined above is the correct one, the results reported here demonstrate the practical necessity of controlling the carbon dioxide concentration in certain types of experiment. For example, it would be invalid to draw any conclusions concerning the effect of metabolic rate *per se* upon radiosensitivity unless it could be demonstrated that change in metabolic rate was not operating through change in intracellular carbon dioxide concentration. Likewise, in testing the effect of temperature, there is the possibility that the results may be modified by the influence of this factor upon the solubility, and hence the intracellular concentration, of the carbon dioxide produced by the cell.

The possibility of clinical application of the results reported here depends upon the answers to the following questions:

(1) Do mammalian tissues, including tumors, vary markedly in radiosensitivity with changes in intracellular acidity as does the fern spore?
(2) If so, are the necessary acidity changes producible within the tolerance range of the mammalian body?
(3) Do the possible acidity changes increase the ratio of the radiosensitivity of the tissue to be destroyed to the radiosensitivity of the tissue to be preserved?

The answers to these questions remain to be determined. If all three answers are affirmative then the results reported here may have clinical application.

SUMMARY

When the spore of the fern *Pteris longifolia* is kept in equilibrium with various concentrations of penetrating acid and base during exposure to soft roentgen rays, the radiosensitivity is markedly different from that exhibited in the absence of these substances.

As the concentration of the penetrating acid, carbon dioxide, is increased from 0 to 20 per cent in the atmosphere (0 to 0.006 M in the culture solution) the radiosensitivity increases from 1.0 to 1.5. As the concentration is further increased from 20 to 100 per cent (0.006 M to 0.031 M) the radiosensitivity decreases from 1.5 to 0.63.

When another penetrating acid, hydrogen sulphide, is used, the variation of radiosensitivity with concentration is similar to that observed with carbon dioxide.

As the concentration of the penetrating base, ammonia, is increased from 0 to 0.01 M, the radiosensitivity first decreases from 1.0 to a minimum of 0.84 at 0.003 M ammonia and then increases rapidly to 1.57 at 0.01 M.

The radiosensitivity of *Paramecium* is markedly increased by 25 and 50 per cent (0.0075 and 0.015 M) carbon dioxide.

None of the concentrations of acid and base used produced any detectable effects without the irradiation.

It is suggested that some connection may exist between the maximum of radiosensitivity observed at 0.006 M carbon dioxide and the maximum of flocculability of proteins when kept at their isoelectric points during irradiation.

It is a pleasure to express here my appreciation of the interest and cooperation of Professor Detlev W. Bronk, Director of the Eldridge Reeves Johnson Foundation.

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DISCUSSION

Dr. P. S. Henshaw, New York City. Dr. Zirkle's paper has dealt with one of the most fundamental problems in all radiology—the problem of radiosensitivity. It is a most remarkable fact that some cells succumb to 40 or 50 r while others can withstand as much as 100,000 r or more. While the tissues of the human body probably do not manifest such wide differences in susceptibility, they nevertheless differ considerably, and it is largely upon this condition that the beneficial results obtained in radiotherapy depend. If it were not that many tumor tissues are more susceptible to radiation than normal tissues the usefulness of radiation in the treatment of tumors would be greatly reduced.

Dr. Zirkle has shown that the radiosensitivity of certain cells can be modified by changing the acid-base equilibrium. This is indeed very interesting in view of the fact that Bergonié and Tribondeau as early as 1906 pointed out that cells in a higher state of physiological activity are generally more radiosensitive than those which are inactive. This condition has been observed many times since and has become widely accepted as a generality. Practically no work has been done, however, to determine whether the activity, as such, is inseparably connected with radiosensitivity.

Recently we have determined the relative radiosensitivity of dry and germinated seeds, and, as was expected, the growing forms were the most sensitive. But, when growth in the germinated material was stopped by lowering temperature, the susceptibility remained high rather than decreasing again to the susceptibility of dry seeds. This indicates that the growth activity and the changes in suceptibility were only indirectly connected. It suggests, furthermore, that the radiosensitivity depends on the physiological condition of the organism, a condition which is responsible for growth rate and which is not modified by lowering the temperature. In this material the physiological condition of the organism was altered by adding moisture in much the same way that Dr. Zirkle modified the physiological condition of his organisms by changing the acid-base equilibrium. While these observations do not actually explain why cells are differentially susceptible to radiation, they do serve to direct attention beyond the condition of activity in the cells.

We have also made an interesting observation on developing *Drosophila* eggs which has a bearing on the subject of radiosensitivity. During the first two hours after fertilization in these forms all of the cells (somatic) present are undergoing rapid multiplication and at this stage the organisms can be killed by dosages of around 200 r. But, at the age of 2–2½ hours differentiation begins and the high mitotic activity is confined to a much smaller portion of the cells. Coincident with the beginning of differentiation the resistance to radiation increases several hundred per cent—a very striking change. Among other things done to account for the large change in sensitivity, sections were prepared of organisms which had been exposed to lethal doses of radiation during the most sensitive stage. It was found that the cell growth was not stopped immediately and that the activity, as far as cell multiplication was concerned, went on unmolested. It appears that the power of differentiation had been lost as a result of irradiation and that death resulted from unrestrained growth of the cells. Some organisms were found which were solid masses of undifferentiated cells. Here a rather paradoxical situation seemed to exist. Death was caused, not by restrained cell growth, but by unlimited cell growth. In this case it seems that the normal restraining factor which acts on the cells at the beginning of differentiation was more vulnerable to radiation than the cells themselves and that the fate of the organism was dependent on this.

This and the remarkable work which has been done during the past few years demonstrating the biological importance of specific agents such as hormones, enzymes, cargemogenic agents, etc., make it seem wise to study the action of radiation on such substances in an attempt to determine why cells are differentially susceptible. It is entirely possible that some of the most important biological changes are produced by the radiation acting directly upon the physiological regulators of activity. Dr. Zirkle's work is a definite step in this direction.

INCISIONAL BIOPSY*

By JOHN M. HANFORD, M.D., *and* CUSHMAN D. HAAGENSEN, M.D.
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AS A working basis in clinical medicine, theories and impressions often take the place of scientific facts. The whole subject of neoplastic disease is notorious for its large dependence upon theories in the working rules of diagnosis, prognosis and treatment. The question of the dangers of the biopsy faces little scientific evidence but the impression is steadily gaining ground that the biopsy in the main is desirable, that its value outweighs its dangers. But, to place this general statement upon a safe foundation requires that many exceptions, explanations and modifications be built under the basic idea. The subjects, for example, of anatomical location, of the nature of the structure involved, of the type of neoplasm, and of the biopsy technique are concerned in reaching acceptable standards.

The object of the biopsy is to obtain from living tissue a sufficient amount of unaltered, abnormal and sometimes of adjacent normal tissue, in order to make all the analyses possible that may be helpful in a given patient. In the case of Hodgkin's disease the diagnosis alone will suffice, whereas in possibly curable carcinoma the gross appearance of the cut section, the character of the specimen on palpation, the grade of malignancy, the radiocurability and the radiosensitivity as well as the accurate diagnosis are often desirable. There is a difference between naming the general diagnosis and defining the details of a biopsy specimen. With the latter procedure the incisional or knife biopsy is concerned.

The factors of importance in obtaining a specimen for thorough analysis may be divided into two groups: (*a*) those that may be harmful to the patient and (*b*) those that may be helpful to the examiner (for the patient). Under the first group are increased local growth, increased spread to regional lymph nodes and the production of distant metastases, besides pain, hemorrhage and infection. Under the second group is an unaltered, clear-cut piece of tissue of adequate size and shape from a selected site. There can be no argument that the scalpel is the best instrument for providing the best specimen for the pathologist. Exceptions to this general rule are readily admitted but they usually represent makeshifts for the want of something better for various reasons. Moreover, where there is little choice, as on the tongue, between a scalpel cut and a high frequency cut, the latter may be theoretically preferable provided an adequate specimen is provided. Yet, within the mouth, the precision of the electric apparatus is not so fine as that of the scalpel. Upon the lip, and indeed in so many sites where the lesion is small and the prospects hopeful, the fineness and precision of a knife make it preferable, both for the tissue left behind and for the assurance of an undamaged specimen. The high frequency tip or loop may be used to remove a large piece from the more extensive surface growths which, on the one hand, may be of the papillary type and thereby less readily "stirred up" by any method, or, on the other hand, so extensive that the prognosis already is bad, and the particular method will make but little difference. The rapidly growing carcinoma which may be most likely to have its spread increased by a biopsy is likewise usually the type in which the most thorough analysis is desirable for prognosis and treatment.

The theoretical serious dangers of incisional biopsy may be indicated by the terms, *pressure*, the *trauma* incident to the control of bleeding, the *opening* of lymph and blood vessels and of tissue spaces, the

* Read in a Symposium on Biopsies at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 10–11, 1935.

pushing of cancer cells into these structures by the knife, the introduction of infecting organisms, the stimulation of increased local growth. It is readily appreciated that the difference in danger, if there is any, between the knife and the high frequency tip or loop, is slight. If the bed of the incisional biopsy be immediately coagulated by a chemical or by the coagulating current, after the use of a fine sharp scalpel, the ultimate results may be the same, with the better surgical technique and the better specimen in favor of the knife.

One of the outstanding advantages of the knife, especially in many breast cancers, is the peculiar sensation, transmitted by the knife to the operator, of the hard texture so characteristic of the disease. This alone may eliminate the need of microscopy and so save operating-room time for the patient. This is lost with instruments other than the knife. With the commonly used novocaine infiltration of the part explored, the high frequency tip adds an increased boiling effect with correspondingly increased necrosis as compared with the clean, uncomplicated strokes of a thin, sharp knife. Generally speaking, too, the total mass damage to the tissue left behind, after the electric procedure, is greater than that after the knife. In the presence of intensive radiation therapy, the less tissue damage there is the better the result of treatment.

There is no intent to discredit the use of aspiration, of the biopsy punch or of the high frequency current tip or loop under some conditions, but it is maintained that a fine, sharp scalpel of suitable size and shape, when used with gentleness and precision, not only in surface neoplasms but in some of the deeper parts, is the best instrument for procuring the most helpful specimen with a minimum of harm to the patient. This contention applies not only to the removal of specimens from obvious disease but also to the removal of suspicious small tumors and of lymph nodes for diagnosis. A knife is a simple instrument and commonly available, but it should be *sharp*.

These conclusions are supported by theoretical considerations, by practical experience and by the absence of scientific evidence in favor of the high frequency cutting current, and, finally, by increasing evidence which indicates that incisional biopsy does no serious harm and that it does provide the best specimen.

In a paper by Dr. Robert B. Greenough, as yet unpublished but quoted herewith

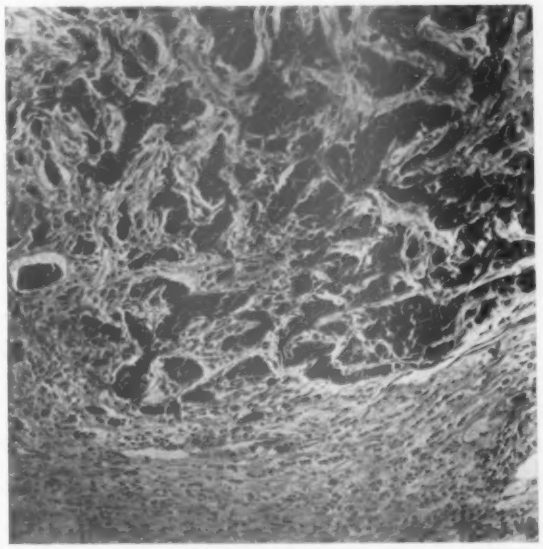

Fig. 1. Case 1. Carcinoma metastasis in axillary lymph node.

by his consent, he refers to a series of radical breast operations in relation to incisional biopsy. Out of 72 patients who had had incisional biopsy before or at the time of operation, 53 per cent gave "five year cures." Out of 310 patients without biopsy, there were 33 per cent "five year cures." This information lends further support to the theory that incisional biopsy of breast cancer is justifiable.

From the histological point of view both aspiration biopsy and endotherm biopsy have the serious disadvantage that they provide specimens in which the natural relationships of cells and fibers are distorted. The criteria upon which we are accustomed to base our diagnoses are disturbed, and the delicate nuances by which we distinguish malignant change may be

FIG. 2. Case 1. The thirteen sections cut from the breast, only one of which, that at the top, shows carcinoma. The entire primary tumor is included in the black circle.

lost. Before we throw overboard the time-honored methods for new, quick, and less precise ways of preparing tissue for diagnosis, let us consider well and seriously the disadvantages of these innovations.

Our most difficult task in diagnosis is to

be sure that we are not missing *small early cancers*. These are the tumors that, as we all know, we have a real chance of curing; here is where mistakes in diagnosis cost lives. And, since the diagnosis of such early cancers is necessarily a histological rather than a clinical one, the method of biopsy is all important. Small tumors of the breast afford a good example of the problem. Illustrations are included of three types of lesions in the breast in which we believe that the aspiration method of biopsy is unsafe.

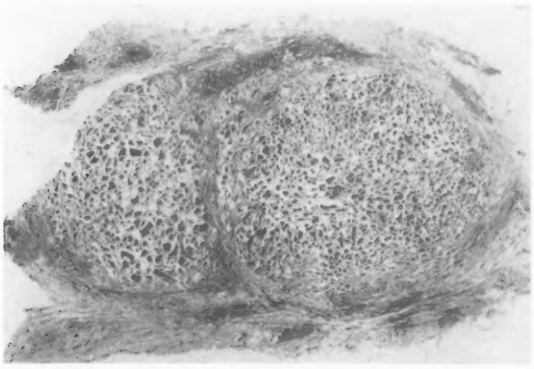

Fig. 3. Case 1. The entire primary carcinoma in the breast.

The first type is the small cancer of the breast. Figure 1 shows the axillary lymph node metastasis in a woman in whom we were unable to palpate a definite mammary tumor. A mastectomy was nevertheless done and Figure 2 shows the thirteen sections which we cut from the breast. In only one section, that shown at the top of the figure, did we find carcinoma. The whole primary tumor is included in the black circle. It is only 0.5 cm. in diameter. Figure 3 shows the whole tumor. It is unlikely that an aspirating needle, no matter how many times it is pushed through the breast, would find this small carcinoma. And the difficulties in aspirating cells from somewhat larger but deep carcinomas in the breast are very great. The aspiration of fluid from a breast tumor may satisfy the physician that he is dealing with a simple cyst and thus lead him to

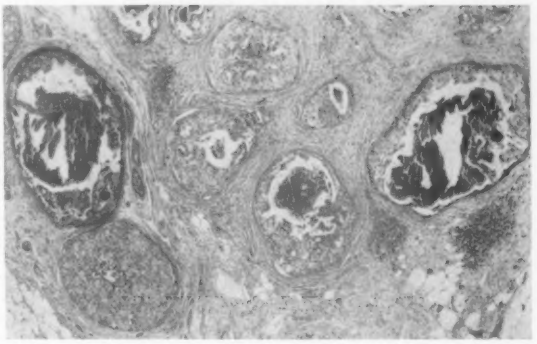

Fig. 4. Case 11. The intraductal type of carcinoma of the breast, sometimes called "comedo tumor."

overlook a small carcinoma which may be associated with the cyst. Auchincloss[1] has described this association.

The second type of breast lesion in which aspiration biopsy is unsafe is the intraductal type of carcinoma, of which Figure 4 is an example. This lesion has been called *pure comedo* by Bloodgood, who regards it as a comparatively benign lesion that does not require radical mastectomy. We have unfortunately seen metastases from this form of intraductal growth and we regard it and treat it as fully developed carcinoma. But it is a type in which the aspiration method of diagnosis is under a great handicap. Even if the aspirating needle penetrates one of these

[1] Auchincloss, H. Surgery of the Breast. Nelson's Loose-Leaf Surgery, 1930, *4*. 870.

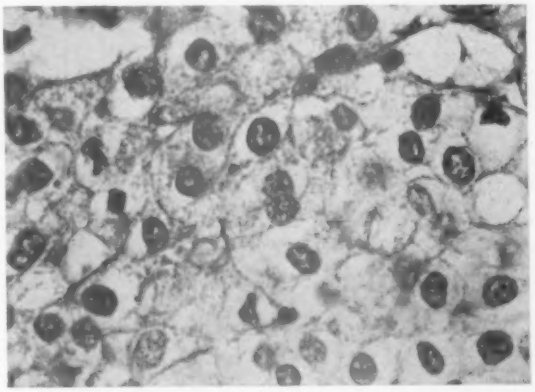

Fig. 5. Case 11. High power view of the comparatively regular cells which fill the ducts in this type of breast carcinoma. ×700.

dilated ducts and secures a small group of the cells which fill them, the pathologist will perhaps fail to recognize the dangerous

raphy of this form of cancer which enables us to recognize it, and aspiration biopsy can hardly reveal this.

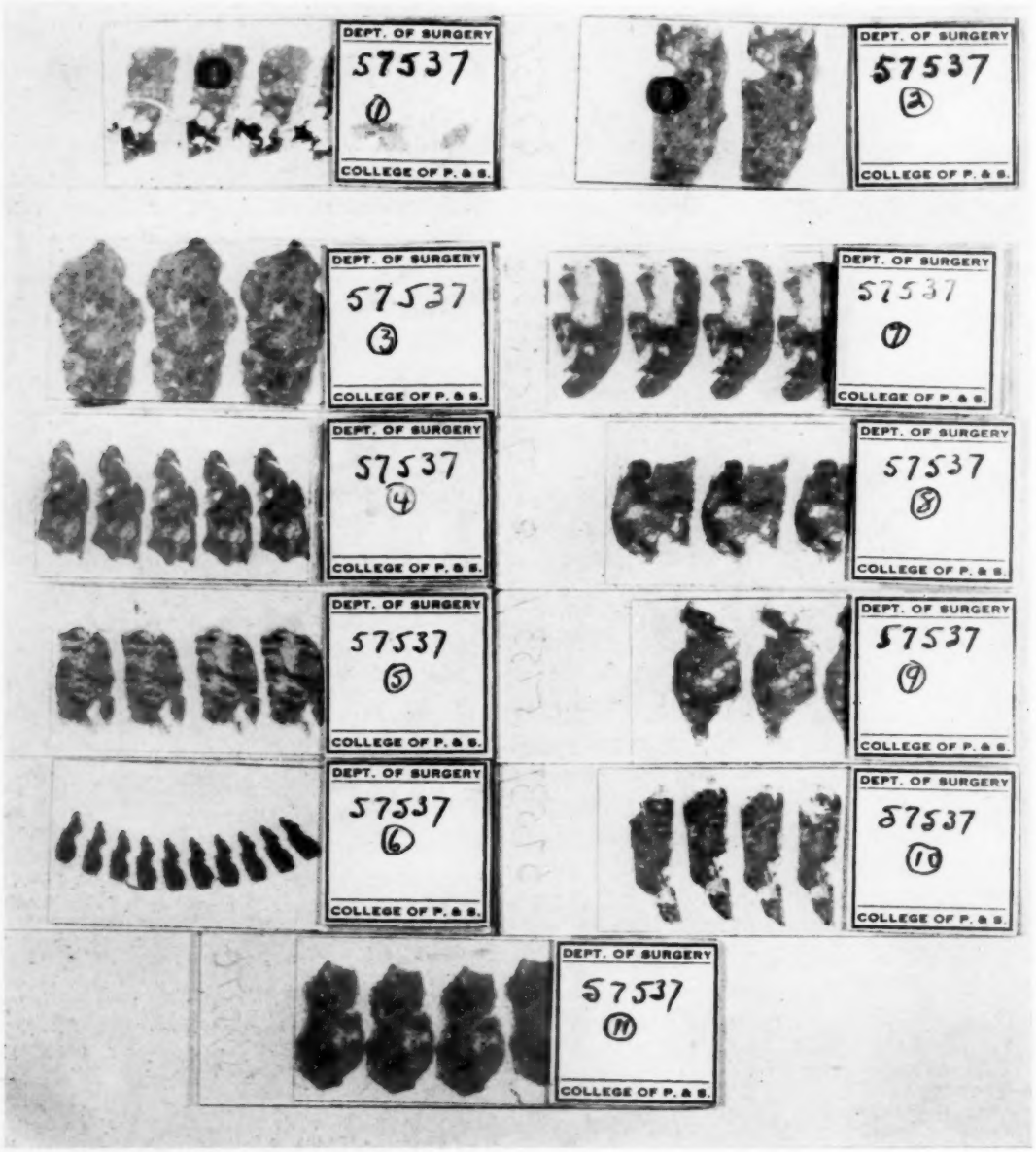

FIG. 6. Case III. Eleven sections cut from the segment excised from the breast. The two top sections showed areas of proliferative change, as indicated by the black circles.

character of the lesion because individually these cells are often well differentiated and comparatively regular. Figure 5 is a high power view of these cells and shows how regular they are. It is the general topog-

A third type of breast lesion in which aspiration biopsy is inadequate is the proliferation of duct epithelium in some forms of chronic mastitis. I need not remind you of the great difficulties which pathologists

face in trying to decide which of the many varieties of epithelial proliferation encountered in chronic mastitis are dangerous, and require simple mastectomy to safeguard the patient from the threat of cancer. The difficulties are increased by the fact that these changes are often widespread in the breast and a few cells secured by aspiration from any one small area cannot begin to tell the whole story.

Here again topographical relationships are more important than the appearance of the individual cells. We want to know the relative size of the areas in which proliferation is going on, just how the cells are growing within the ducts, whether or not

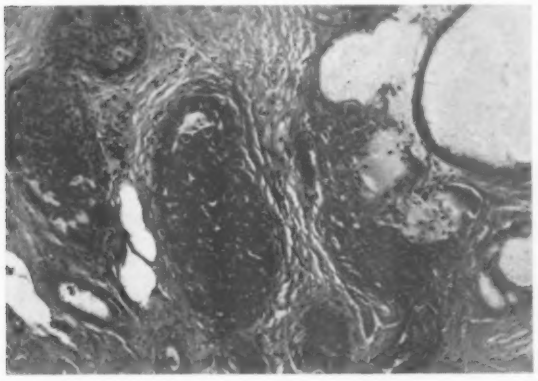

Fig. 7. Case III. Papillary processes filling the ducts.

they form papillary processes, and the orderliness of their arrangement. A recent case of Dr. Auchincloss' illustrates these problems. He excised a segment of the breast for a small tumor which proved to be a smooth-walled cyst containing a papilloma. The eleven sections shown in Figure 6 were cut from this specimen. In only two of these did we find anything but simple cystic mastitis. In one section which is shown at the top on the left of the figure, we found an area in which dilated ducts were filled with papillary processes (Fig. 7). This was interpreted as being a benign process. But, in another section which is shown at the top right of Figure 6, a small area was found in which there was a striking proliferation of small ducts (Fig. 8). Here it was extremely difficult to determine whether or not there was invasion. After the most careful study we were unable to decide whether or not we were dealing with early carcinoma. Under such circumstances, simple mastectomy was advised. We feel that we still have a great deal to learn regarding the significance of the various forms of epithelial proliferation in chronic mastitis, and we believe that we can learn only by studying numerous histological sections of well-fixed tissue removed with the knife from these cases, and by a long continued follow-up of the patients.

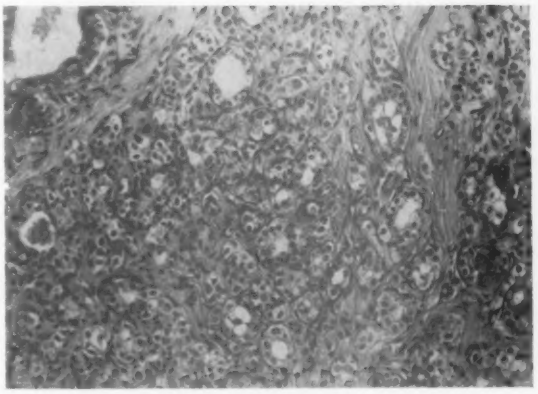

Fig. 8. Case III. Proliferation of small ducts.

But Dr. Stewart in the paper following will say that he relies only on aspira-

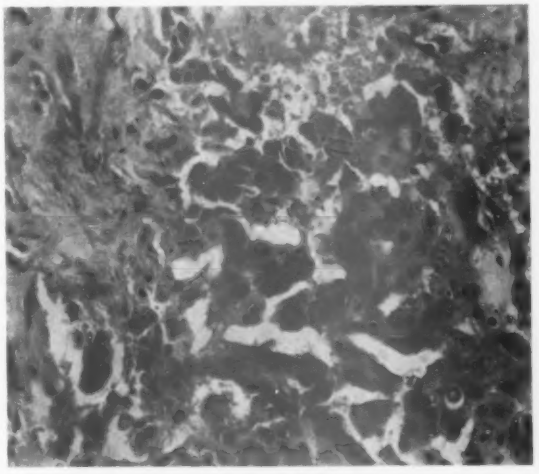

Fig. 9. Case IV. Shrinkage and loss of cell detail in breast carcinoma, resulting from the use of the endotherm method of biopsy.

tions which give a positive diagnosis. Even if this limitation is placed on the method we still find it unsatisfactory. Pathologists are accustomed nowadays to attempt to estimate the degree or grade of malignancy as well as the radiosensitivity of tumors.

In Dr. Stout's laboratory at the Presbyterian Hospital we try as well as we can to answer these questions. We base these predictions on a number of histological characteristics which appear in varying degrees in tumors. These include, in squamous cell carcinoma, the extent of pearl formation and stratification of the tumor cells, the degree of hyperchromatism and variation in cell size and shape, the frequency of mitosis, and the presence of intercellular bridges, and of keratin. These features are best shown by the trichrome stain of Masson.[2]

In adenocarcinoma we estimate the probable degree of malignancy on the basis of the presence of an orderly adenoid arrangement of the tumor cells, their variation in size and shape, their hyperchromatism, the frequency of mitosis, and the tendency to secrete mucin. This latter characteristic is best shown by Mayer's mucicarmine stain.

[2] Masson, P. Some histological methods; trichrome stainings and their preliminary technique. *J. Techn. Methods*, 1929, *12*, 75–90.

We do not mean to say that these characteristics enable us to foretell with much regularity the grade of malignancy and radiosensitivity. In many types of tumor we are at a loss what to predict, and our predictions are often wrong. But we are studying these and other histological characteristics in every tumor and attempting by means of a careful follow-up of the patients to learn to correlate the morphology of tumors with their clinical course.

This type of histological study requires ample tissue removed undamaged, and properly fixed. Incisional biopsy is, we believe, the best way of securing such tissue. In aspiration biopsies the cells are crushed and their relationships disturbed. In endotherm biopsy, as Figure 9 illustrates, dehydration which occurs in the tissue causes shrinkage as shown by the presence of clefts between the cells, and destroys to a considerable extent the fine details of cell structure.

In conclusion, we prefer to base our diagnoses on tissue which has been removed with the knife rather than by any other method, which has been properly fixed, and from which a number of sections have been cut and stained in a variety of ways.*

* For discussion see page 254.

Vol. 35, No. 2

THE ADVANTAGES AND LIMITATIONS OF ASPIRATION BIOPSY*

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and
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ASPIRATION biopsy is a time-saving method of securing tissue for histological examination without surgical incision through normal tissue. If the growth is ulcerated on the surface of the skin, or any accessible mucosa, there are no advantages in or indications for the use of this method in place of the ordinary biopsy, and in such cases, an ordinary biopsy should be taken directly from the surface with a forceps or scalpel. The larger preparations so obtained are of course preferable to the smaller specimens or smears of aspirated material. Aspiration biopsy is indicated only in tumors which lie below the surface, where an incision through normal tissue would otherwise be necessary to obtain a specimen.

In tumors which lie below the surface of normal tissue, the extent of the operation in surgical biopsy and its disadvantages vary, depending on the anatomical location of the tumor. In the case of an isolated, superficial and movable node, there are no objections to surgical exposure and total removal of the node for biopsy from the standpoint of safety. But, in any event, surgical biopsy in such cases usually requires admission to the hospital, and involves a certain amount of discomfort, expense and loss of time to the patient. In most of these cases, histological information of almost equal practical value can be readily obtained by aspiration, without any of the above mentioned drawbacks.

In the second group, such as tumors of the bones, breast, abdominal cavity, maxillary antra, and various non-encapsulated subcutaneous tumors, surgical biopsy is attended by some operative risk, or danger of postoperative wound infection or fungation of the tumor through the operative wound. In this group, the advantages of aspiration biopsy are at once apparent, if histological verification of the diagnosis is necessary before outlining treatment. We believe that a preoperative aspiration biopsy is preferable to a frozen section during the operation.

In a third group, of cases, the surgical approach to the tumor is so extensive and serious a procedure as to be unjustified for the purpose of obtaining a biopsy alone, and in these, aspiration is the only possible means of securing material for histological examination. Tumors of the lung, not accessible to the bronchoscope, prostatic tumors and advanced inoperable tumors without surface ulceration are some examples of the latter group.

The deeply adherent scarring which commonly follows incisional biopsy through normal tissue is a definite disadvantage to subsequent therapy either by surgery or irradiation. The tendency of previously encapsulated masses toward wide infiltration into the tissues or even toward fungation through the operative wound are complications quite commonly observed in our clinic, especially in cases referred to us for treatment after poorly conceived or executed incisional biopsy. Aspiration is attended by none of these dangers.

An attempt to enumerate and describe in detail the many situations where aspiration biopsy is of value in the diagnosis of tumors would require more time than is

* Read in a Symposium on Biopsies at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 10–11, 1935.

available today, and furthermore, a full discussion of these matters, as well as a detailed description of the technique, has already been published[1,2] and will not be repeated here. It must be sufficient, at this time, to state that by this method, it is possible to obtain histological diagnosis of malignant tumors in about fifteen minutes, and that the procedure may be carried out in the clinic or office under local anesthesia, without special apparatus, special preparation or undue discomfort to the patient.

The successful employment of aspiration biopsy depends, to a large extent, upon a sympathetic cooperation of surgeon and pathologist. All that can be definitely expected from the pathologist is a statement as to whether the lesion is or is not a malignant tumor. It is often possible to go further and to indicate the type of tumor, or even granuloma, especially if the pathologist possesses complete clinical data and is familiar, through experience, with the tumors or other lesions common to the region involved. A shrewd guess as to comparative malignancy may be possible. The notion seems prevalent that the interpretation of aspiration biopsies is something vague and difficult. This is really quite erroneous. It naturally involves a rearrangement of ideas on histological diagnosis, since one has to interpret distorted patterns of cells which have lost their normal relationships, wholly or in part. But this is not difficult, provided the pathologist will learn by smearing out gross specimens received in the laboratory and comparing the pictures produced with the actual structures of the eventual section. A full discussion of the pathological interpretation of these small biopsies and tissue smears has already been published.[3]

It is interesting to note that in 1927, Dudgeon and Patrick[4] reported upon "wet film" diagnosis of tumors and found the method very successful. The only difference between their wet films and our own smears is that theirs were prepared from gross specimens, whereas ours are made from aspirated material. Their figures show that the material they interpret is exactly similar to ours. They find that "experience is required for this rapid method, as for all other laboratory methods, and it is essential to possess a sound knowledge of the microscopical study of new growths and inflammatory tissues by the usual technique." As is true, to some extent, in all forms of biopsy, a negative report is of little value in diagnosis.

The pathologist should realize that although the evidence upon which he is asked to express an opinion may be less than he would prefer, nevertheless, any positive information he may give will be of great value to both the surgeon and the patient. He should consider that the small tissue fragment was obtained with much less risk, delay and discomfort than would have been the case with incisional biopsy. The surgeon, on his part, must be satisfied with less than the usual detailed report.

If one admits the several advantages of and indications for this procedure, there still arises the question as to whether there is any danger involved in puncturing various tumors and viscera with an 18-gauge needle. This question must be answered from two standpoints: First, is the puncture itself dangerous in certain anatomical localities such as the lung, abdominal cavity, or the neighborhood of large blood vessels? In a series of over 3,500 cases aspirated in the Memorial Hospital, we can confidently state that we have observed no untoward symptoms or sequelae, although such regions as the lungs, liver, spleen, prostate, orbital cavity and neck have been repeatedly aspirated. Obviously, the abdominal cavity must be approached with some discretion with a sharp pointed needle, but in many instances, we have safely and successfully aspirated abdominal tumors after reasonable assurance by palpation that there was no intervening intestine.

Secondly, the question will arise as to whether the procedure is dangerous because it may tend to favor the spread of metastases. Any opinion in this regard is

very difficult of proof. In our experience, we have not observed earlier or more frequent metastases in aspirated cases. In preparing a recent report on cervical nodes, we found a group of 60 cases of cervical metastases in our clinic proved by aspiration, which were free of disease from one to six years following treatment by radiation. Large groups of cases, such as this one, have convinced us that aspiration biopsy carries with it no objection from this standpoint.

Histological proof of cancer is, in most cases, absolutely essential before one is justified in proceeding with the necessarily radical treatment, either by surgery or irradiation. Any procedure which makes it possible to secure histological diagnoses more readily, in a greater percentage of cases, and with greater facility in difficult situations is, we believe, a worthwhile addition to the measures already in use in the management of this disease.*

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* For discussion see page 254.

ELECTROSURGICAL BIOPSY*

By GRANT E. WARD, M.D., F.A.C.S., *and* CHARLES F. GESCHICKTER, M.D.
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ELECTROSURGERY is the application of high frequency electric currents for the destruction and removal of diseased tissue or for cutting through normal tissues with diminished bleeding" (Kelly and Ward). Biopsy is "inspection of the living body, as opposed to *necropsy;* especially diagnostic examination of a piece of tissue removed from a living subject" (Dorland). Electrosurgical biopsy then is the removal of diseased or supposedly diseased tissue from a living subject for diagnostic examination using a high frequency electric current to control bleeding, and, we will add, to prevent dissemination of malignant cells or infection by closing lymphatics and blood vessels. Tissue is removed directly from surface growths, usually ulcerated, on the skin or in accessible cavities, or from more deeply situated tumors by incising the overlying integument and other structures, exposing the growth to be biopsied, and closing the wound, after taking the specimen. Electrosurgical biopsy is not a replacement of all other forms of obtaining tissue for diagnosis, but is an indispensable adjunct in studying malignant growths, especially vascular ones, and is many times the safest form of biopsy.

EQUIPMENT

Apparatus. Any standard electrosurgical generator producing cutting and coagulating currents is satisfactory. A machine which will produce only a cutting current is hardly suitable, for occasionally bleeding occurs which requires coagulation.

Cutting Current: An electrosurgical high frequency current can be made to sever tissue as quickly and accurately as a scalpel. All gradations of destruction along the cut edge from 0.1 mm. to 1 mm. can be obtained, depending upon the type of apparatus and strength of current and time taken to make the incision. Cutting currents from vacuum tube generators ("undamped" wave currents) (Fig. 1) usually yield the best primary union for the heat is concentrated in a minute area. When the current strength is increased, more rapid cutting is obtained up to a certain point—beyond which there is more marked destruction of tissue, particularly when cutting with a current from a spark-gap generator. Here the waves are of the damped variety (unequal oscillation) and flowing in chains.

Coagulation Currents (Fig. 2): These may be produced by a tube or spark-gap generator, but the latter is preferable. There seems to be something about the damped waves flowing in chains which produces more even and deeper penetrating coagulation. In certain vascular areas, even though biopsy is made with a strong cutting current, there may be some bleeding, which is quickly controlled by applying the coagulation current on a rod-like or ball electrode. This leaves a sterile field upon which cells cannot be transplanted or from which dissemination cannot occur through lymphatics. Even when the tumor is located deep in some subcutaneous structure, such control of bleeding and dissemination is accomplished and the wound closed over it. The electric current sterilizes the tissues, the coagulum being absorbed without delay in healing.

Blended Current: Recently an apparatus has been developed where the cutting characteristic of the radio tube current is blended with the coagulating property of the spark-gap generator and this dual or blended current can be passed over a single electrode. Where a biopsy is necessary in

* From the Surgical Department of the Johns Hopkins Medical School and the Surgical and Oncological Departments of the University of Maryland. Read in a Symposium on Biopsies at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 10–11, 1935

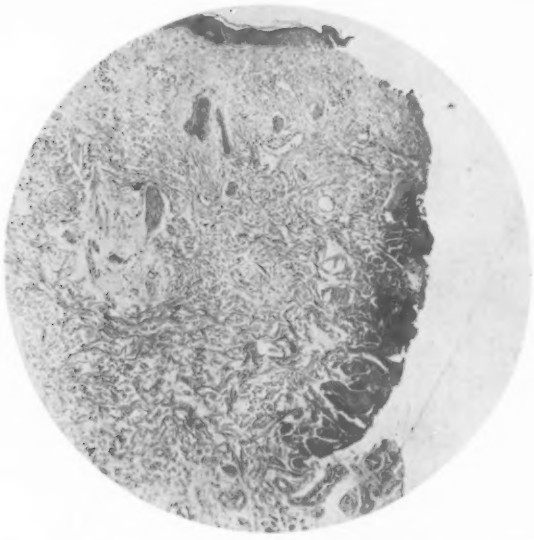

Fig. 1. Photomicrograph of edge of incision made with electrosurgical radio tube cutting current. Small line of destroyed tissue readily absorbed and primary union results.

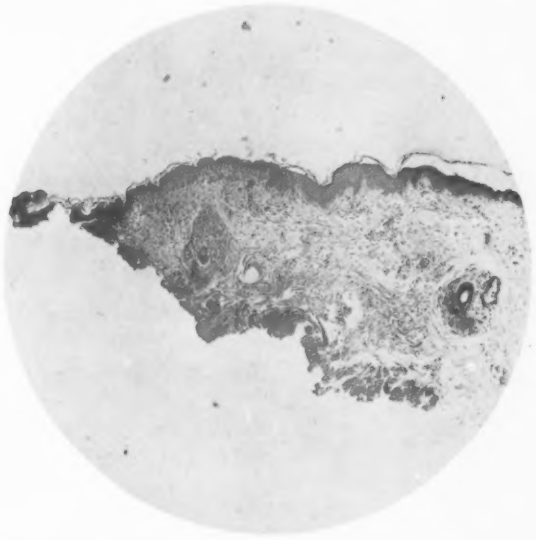

Fig. 2. Photomicrograph of edge of incision for removal of fibroma of the upper eyelid. Apparatus: spark-gap type, uniterminal setting. Result: primary union.

a vascular area, a scallop of tissue can be looped out with the blended current, leaving a dry area behind, as coagulation of the tissues takes place simultaneously with cutting.

Electrodes: For usual electrosurgical biopsy, three types of electrodes are necessary (Fig. 5): (1) Wire loop carrying a cutting current of varying strength is used to scallop out a small piece of tissue from accessible and ulcerated malignant disease. Tumors of the skin, lip, mouth and

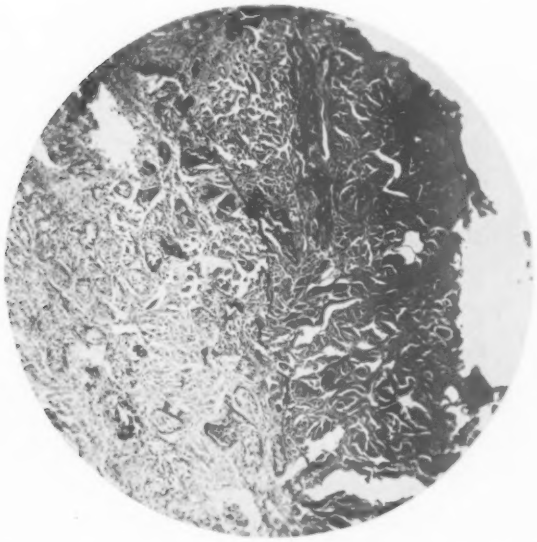

Fig. 3. Photomicrograph of edge of incision made with heavy spark-gap cutting-coagulating current serviceable in controlling hemorrhage in vascular tumors. (From Kelly and Ward[1].) (Courtesy of W. B. Saunders and Co.)

Fig. 4. Photomicrograph of edge of incision made with heavy blended current (radio tube blended with spark-gap current). This blended current cuts rapidly and steadily, and simultaneously coagulates efficiently. (Courtesy The Burdick Corp.)

other accessible areas are amenable to loop electrosurgical biopsy. The optimum size of such a loop is approximately 1 cm. in diameter. Wyeth has emphasized the value of a diamond-shaped electrode as the point of the diamond cuts into the tissue more quickly than a rounded loop. The wire loop is valuable to scallop out a piece of a deep-seated tumor which has been exposed by surgical or electrosurgical incision (Fig. 7). (2) A small, flat electrode about 2 mm. wide and 1.5 cm. long, held in a suitable handle, is excellent for excising surface tumors or those more deeply situated. The electrode may have a rounded or sharp point as desired. The width of the electrode makes for a longer application of the current while cutting and gives more complete hemostasis and sealing of lymphatics than does the originally used needle or wire-loop electrode. (3) A rod-like, or ball electrode coagulates any remaining bleeders after the biopsy is taken; this is of particular value in an exceedingly vascular area (Fig. 6).

Anesthesia: In practically all cases, electrosurgical biopsy requires some type of anesthesia. Usually 2 per cent procaine is sufficient, either for the removal of tissue from an ulcerated or accessible growth (Fig. 6), or a deep-seated tumor.

TECHNIQUE

Loop Dissection. Given a problem of biopsy from an accessible lesion, for example, ulcer of the lip, the technique would be about as follows: Alcohol wash, particularly of the skin around the ulcer and infiltration with 2 per cent procaine at a safe distance. A wire loop of suitable size is chosen, say 1 cm. in diameter, and usually with a single stroke a scallop of tissue is removed. If the ulcer is small, all of it is taken in one section, if large, only a portion should be removed. The stroke of the instrument should be slow and

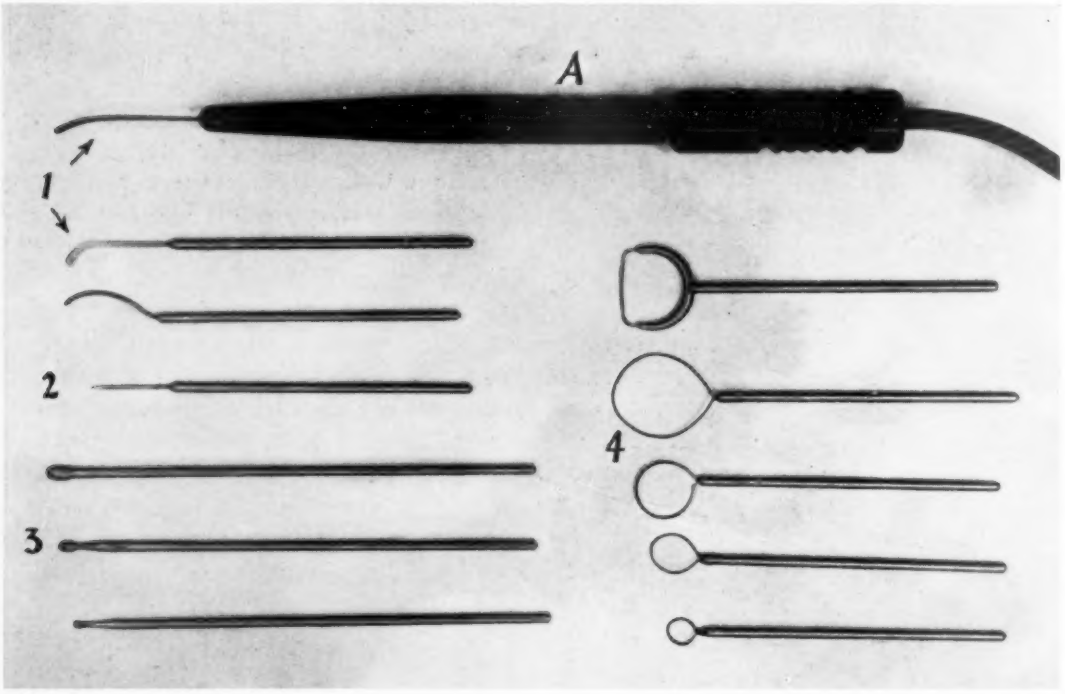

FIG. 5. Instruments for electrosurgical biopsy. *A.* Insulated handle to hold electrodes. 1. Cutting blades. 2. Needle. 3. Ball coagulating electrodes to control bleeding. 4. Assortment of wire loops for scalloping cut tissue for biopsy. (From Kelly and Ward[1].) (Courtesy of W. B. Saunders and Co.)

steady securing thorough hemostasis and sealing of lymphatics, but not slow enough to allow time for all the tissue in the biopsy specimen to become changed by heat. Any residual bleeding from a large vessel is easily controlled by applying a ball electrode, carrying a coagulating current, or, if the bleeder is large, by clamping with a suitable hemostat and passing the coagulating current down the clamp to seal the vessel.

Electrosurgical Cutting. This is desirable for biopsy from a lymph gland or a deep tumor. The skin over the tumor is treated by any suitable preoperative aseptic technique and the skin infiltrated with procaine. The normal tissues are incised with the scalpel or electrosurgical cutting current. When the tumor is exposed, but not cut into, a wire loop carrying a strong cutting current scallops out the necessary amount for biopsy (Fig. 10). Here a larger loop,

Fig. 6. Large vascular malignant tumor of face. Aspiration biopsy diagnosis ten months before: malignant pigmented mole; electrosurgical biopsy (Figs. 8 and 9): extramedullary myeloma.

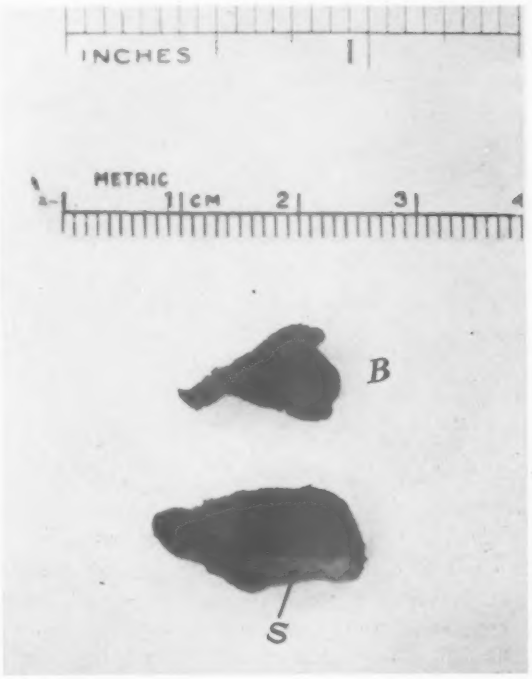

Fig. 7. Scallops of tissue removed with electrosurgical loop (4, Fig. 5) from *B* in lesion shown in Figure 6. Less than 1 c.c. of blood lost. Base from which scallops were removed was coagulated with ball electrode (3, Fig. 5). Anesthesia, 2 per cent procaine. *S*. Skin with piece of tumor attached. *B*. Scallop from deeper within tumor.

12 to 14 mm. in diameter, is needed. It may be desirable to use a flat, knife-like electrode and excise an elliptical piece for section. Be that as it may, the stroke should be slow and steady to secure even coagulation of the cut edges. Again, any oozing or bleeding from large vessels may be treated as above described. The wound is closed without drainage for the coagulated tissue will readily be absorbed, without complications.

HISTOLOGY

Light cutting is best obtained from a radio tube circuit (Fig. 1) but, by properly adjusting a spark-gap apparatus, a cutting current can be obtained which will yield primary union (Fig. 2). This current should be of the right strength to permit the electrode to pass through the tissues rapidly enough to limit the destruction on each side of the incision. Two theories are

Fig. 8. Low power photomicrograph of scallop shown in Figure 7. Note coagulated edge with sealed capillaries and lymphatics aiding in limiting metastases.

offered to explain electrosurgical cutting: one attributes the cutting to a molecular disintegration of the tissues by the rapid bombardment of the high protein molecules by the oscillations of the high frequency current; the other theory assumes that the heat generated in the tissues is sufficiently high and of such concentration as to part them by dehydration and coagulation of the cells, actually boiling the cells in their own juices.

Microscopic examination of the cut edges reveals two distinct layers of destruction: the first a thin line of finely divided particles of carbon due to the breaking down of protein molecules either by heat or molecular disintegration; back of the first lies the second, a broader layer of dehydrated and coagulated tissue with sealed lymphatics and capillaries. It is possible to keep the combined width of these layers of destruction down to as low as 0.1 mm.

Heavy Cutting. In removing tissues from vascular areas, a much stronger and more deeply coagulating effect is necessary to control hemorrhage and possible dissemination of malignant cells. Such strong cutting currents are generated preferably by a spark-gap circuit, producing a damped wave. Inasmuch as no current flows between each chain of oscillation, time is given for the heat to penetrate more deeply into the tissues. Certain radio tube generators are made to produce a heavy cutting current but not without a flame-like spark which obscures the line of incision and is less accurately controlled than the spark-gap or finer tube current. None of the heavy currents permit primary healing. This is not always important, however, as most of these vascular lesions appear in some cavity where primary union is not possible or the tumor may lie deeply beneath the skin requiring exposure through an operative incision. The biopsy is looped out and the wound closed over it.

Under the microscope the coagulation destruction is seen to extend from the incision line back for a distance of 60 or 70 microns or farther. Figure 3 shows clumps of tumor cells destroyed by the heat much farther from the incision line than the stroma cells. This is probably due to the fact that tumor cells are more vulnerable to heat than are normal stroma cells.

Coagulation. The defects remaining after removal of tissue for biopsy frequently

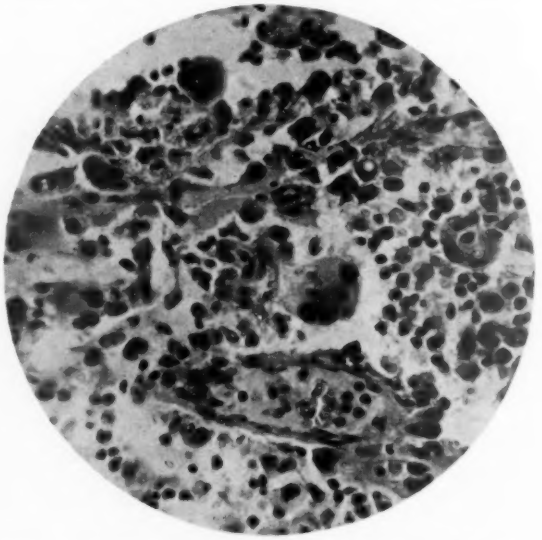

Fig. 9. High power photomicrograph of Figure 8. Note that there is no injury to cells from heat and excellent pathological study is possible.

require reapplications of a coagulating current on a rod or ball electrode to secure thorough hemostasis and destruction of all surface tumor cells before closing the wound. Electrocoagulation is accomplished by raising the temperature in the tissues well beyond the boiling point so that the cells are accurately coagulated in their own boiling juices. With the usual application, stroma cells tend to remain faintly outlined with scattered nuclei in the hyalinized mass, appearing shrunken and elongated. Other cells, particularly tumor cells, suffer more complete destruction and are partially exploded by the steam formed within, obliterating their identity. Those receiving the most heat are completely coagulated into a uniformly staining residuum. In Figures 3 and 4, blood vessels are closed by mass coagulation; sometimes they are clamped, and the intima is sealed together by the heat of the current.

SAFEGUARDS

(1) Be sure to obtain enough tissue, an important consideration in any form of biopsy.

(2) Be sure not to destroy too much tissue. Excessive destruction is prevented by using a current which cuts rapidly enough to allow the electrode to pass steadily through the tissues; too slow incisions allow time for deep destruction. A sufficiently large loop will prevent destruction of cells in the central portion of the scallop or sphere of tissue removed (Figs. 9 and 11). If the biopsy is taken with a small blade electrode, any size piece can be obtained without damage to the center of the specimen.

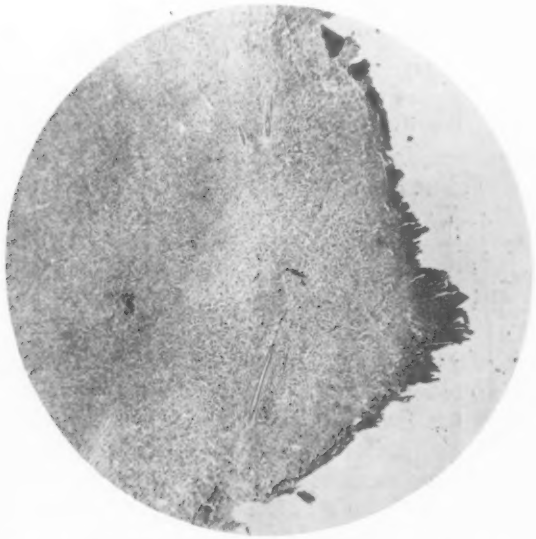

Fig. 10. Low power photomicrograph of edge of scallop removed by electrosurgical wire loop electrode carrying spark-gap cutting current. Note coagulated edge but normal architecture of center of scallop maintained for pathological study.

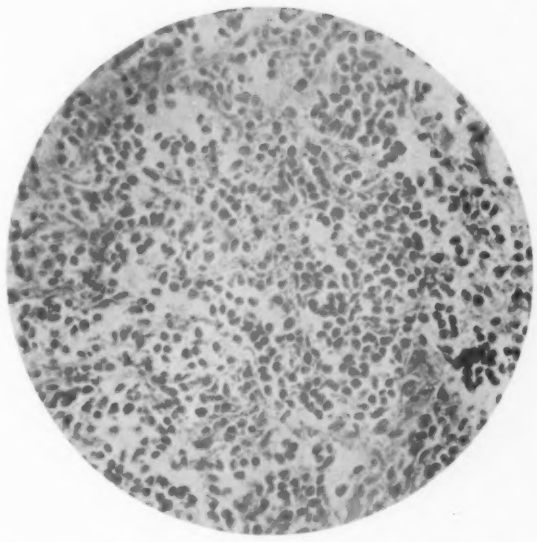

Fig. 11. High power photomicrograph of Figure 10. Note detail of tumor architecture.

ADVANTAGES

(1) Biopsy is taken with a minimum amount of bleeding.

(2) Tissue is obtainable from vascular areas otherwise impossible.

(3) Any desired amount of tissue may be obtained.

(4) Safer than scalpel biopsy as there is no dissemination of cells through the lymphatics and capillaries, and the area from which the tissue is removed is sterilized, reducing danger of implantation to a minimum.

(5) No undesirable effects have been noted in the last ten years by the employment of this method, except in a few cases where a larger scar resulted than would have with scalpel surgery, seen most com-

monly in lip or skin. This additional scarring is compensated for by the advantages enumerated.

(6) Complete bloodless removal of small, precancerous lesions without danger of dissemination.

(7) It can be employed in the office as well as in the hospital.

(8) Distortion of tissue by heat is held at a minimum by proper technique without interfering with the pathologist's diagnosis.

(9) Biopsy from bladder tumors is obtained with a resectoscope through a cystoscope.

DISADVANTAGES

(1) Electrosurgical biopsy is a painful procedure and requires local anesthesia.

(2) It requires a moderately priced instrument and more elaborate equipment than with scalpel or aspiration biopsy.

(3) The surgical technique for deep-seated tumors is more elaborate than with aspiration biopsy.

(4) With improper technique cells for study may be changed by the heat.

(5) There is sometimes more scarring than with scalpel biopsy of lip and skin precancerous lesions.

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DISCUSSION OF SYMPOSIUM ON BIOPSIES*

DR. FRED W. STEWART, New York City. The proponents of aspiration biopsy have never claimed its superiority over ordinary biopsy methods but only its applicability to areas not readily accessible to ordinary methods. They fully appreciate its limitations. Some of the cases Dr. Haagensen presented as arguments against aspiration are not arguments at all. Of course one cannot see such beautiful keratinization in orderly arrangement in a smear but in that case we wouldn't have taken a smear since it was undoubtedly an ulcerated tumor. Furthermore, we are after a diagnosis in our cases and not a demonstration of histologic technique. In the breast tumors he shows, aspiration would not have been applicable in the one for from his story I take it that the breast mass could not be felt and what one can't feel, one can't aspirate. In the second I am not sure that aspiration would have yielded such disastrous results of interpretation since I do not think what he has shown as cancer in a lantern slide is cancer.

Dr. Haagensen states that you cannot grade a tumor from aspiration; doubtless true, sometimes false. That is not what we are after. We want first of all diagnosis and are only secondarily interested in grade, which after all is something of interest in *group* prognosis.

DR. JOHN M. HANFORD, New York City. I am not a pathologist but if I were I would think it sort of a roundabout method to tear apart normal tissue in order to study what it looks like when torn apart by the aspiration biopsy. I cannot see the practicability of that. I can see the occasional use of aspiration biopsy. The patient may object to any other procedure. It may establish the diagnosis and I think no one can say that it has not very definite indications occasionally. The main issue I would say is this: If we are to learn more and more about these neoplasms we must have better and better specimens. We must learn as much as we can about the best kind of specimen, so the aspiration biopsy while it may be useful in some cases is after all a makeshift. It may take special technique and special knowledge to interpret it and that is all to the good, but it is still a makeshift that is used in place of something better. If we do it we should do it well, but the less we do it I think the better.

DR. CUSHMAN D. HAAGENSEN, New York City. Dr Stewart said aspiration biopsy is not used in a competitive sense where incisional biopsy would be used, but I wish to ask him if it is not the custom to diagnose lesions of the breast at the Memorial Hospital by aspiration biopsy. Certainly this is a situation in which we customarily use incisional biopsy. Moreover, it is our experience that breast lesions are among the most difficult to diagnose.

It is very nice to see the excellent pictures of individual cells that Dr. Stewart showed, but I think it is a general feeling among pathologists that the diagnosis of cancer is often dependent upon histological rather than cytological evidence. Evidence of invasion is usually necessary, and to get this one must have for study tissue in which the natural

* Papers of Hanford and Haagensen, Martin and Stewart, and Ward and Geschickter.

relationships of cells and fibers are preserved. We believe that such tissue is best obtained by incisional biopsy. Good fixation is also necessary, and in this regard it should be added that we find formalin unsatisfactory, because of the excessive shrinkage which it causes. We prefer Zenker's fluid, although Bouin's fluid gives rather good results with some types of tissue and has the advantage of being simpler to use.

Dr. Fred W. Stewart. Dr. Haagensen accuses us of making diagnoses of breast cancer by aspiration, and asks for explanation. In my paper I mentioned the applicability of aspiration biopsy to methods in use in the Memorial Hospital. Dr. Haagensen is quite familiar with these methods. Our breast tumors are treated by preliminary fractionated doses of roentgen rays or radium. I am not arguing the correctness of this procedure. I do not know. I do know, however, that we prefer not to incise these tumors prior to irradiation and hence we obtain diagnosis by aspiration. The same applies to many other tumors to be treated by irradiation.

Dr. Haagensen speaks of aspiration being a cytologic diagnosis, and refers rather disparagingly to such methods. I do not agree that it is a one cell diagnosis. Every smear you saw contained thousands of cells and some had very definite arrangements. Of course to one who merely wishes to study pretty histological sections aspiration is out of the question, but if one is interested in the immediate applicability of diagnosis to planned treatment, it is quite another matter.

Dr. Charles F. Geschickter, Baltimore, Md. I think we are fortunate to have three different methods of biopsy and to have a number of groups of investigators, interested and informed on the different methods.

There are occasions when one method of biopsy is preferable to another. Aspiration biopsy is objectionable to many pathologists but is to be preferred when a large, apparently inoperable tumor is present. In such cases aspiration biopsy confirms the clinical impression, avoids the error of starting an operative procedure which cannot be finished and supplies a microscopic record and basis for prognosis in non-operative procedures. In vascular or infected lesions particularly in the oral cavity the cautery loop described by Dr. Ward is the preferable method of biopsy. In other locations where the tumor is deep and where major surgical procedures are contemplated, incisional biopsy with a frozen section report which can be returned in a few minutes is advantageous.

All of these methods have their peculiar disadvantages. Where interpretation cannot be made from an aspiration biopsy, no other tissue is available for paraffin section or for further staining technique without repeating the biopsy. Particularly in lesions of the lymph nodes where permanent sections which show the capsule of the gland are desirable for diagnosis, aspiration biopsy has its drawbacks. One advantage of aspiration biopsy is that no surgeon is necessary for the procedure, a point which has its appeal to both the radiologist and pathologist. One disadvantage of incisional biopsy in breast tumors is the tendency for the surgeon in small benign lesions to include too much mammary tissue in his alleged biopsy procedure, so that a cosmetic defect results. In the cautery biopsy the tissue may be seared and the cells distorted.

In discussing biopsy one usually considers convenience to the practitioner, to the tumor or to the patient. The pathologist is rarely consulted. It is well to bear in mind, however, that where the pathologist is the court of last appeal and where he is relied upon for a final diagnosis, the type of biopsy should be suited to his needs. It is well to consult the pathologist in the case and determine what method is preferable from his point of view. If such a consultation is attempted, would it be asking too much for the clinician to supply some of the clinical history or the radiologist to show the films?

Dr. Francis Carter Wood, New York City. This has been a very interesting discussion and it seems to me that in many points all three speakers, while differing in some degree, were nevertheless right. Everyone acknowledges that before we treat any condition, whether a malignant growth, inflammatory tissue or borderline lesions, like Hodgkin's disease for instance, it is best to know what we are going to treat, and in most instances this requires material for examination. The way in which we get that material, it seems to me, depends largely upon the situation which is to follow. I think it is perfectly correct to say that if carcinoma of the breast is to be treated with preoperative roentgen irradiation a large incisional biopsy should not be done as the wound will not heal. Some form of punch or aspiration biopsy must be done which will not damage the tissue if preoperative irradiation is to be used. It is true that such biopsies are not new. Some thirty-five years ago Dr. Robert Abbe of St. Luke's Hospital, New York, used

to puncture breast tumors with a large needle and bring the tissue to me for examination, but the cells were so damaged and not infrequently torn blood vessels were included that I solved the difficulties by refusing to make diagnoses on such material. These are the dangers in hands that are not skilled, and it is true, as Dr. Stewart has hinted, that it puts a very considerable burden on the pathologist, to ask him to give any opinion on material obtained by puncture, but I have a feeling that there are exceptions, such as Dr. Stewart mentioned. Personally I prefer to see untraumatized and well fixed material. After all, the diagnosis of any material by anyone, no matter how expert, is not always easy. Very often it is impossible with lymph nodes to be certain of the process that exists, unless you wish to place the lesions in one group and call them all lymphoblastomas. Most people, however, believe that it is better to differentiate between the different types of lymphoblastomas such as those which can profitably be irradiated, as the large follicle tumors which can be effectively handled over a long period of years, in contrast to the other type which is fatal within a few months. I think Dr. Stewart will agree with me that it is best to have a lymph node excised in order to give ample material. I am only giving this as illustrative of a situation where we need an incisional biopsy. The situation in the breast is entirely different. If a patient is under an anesthetic and the surgeon is in doubt about the growth, I think it is entirely unnecessary to do a biopsy on the average breast case, a gross inspection is all that is needed; but in the unusual examples the biopsy can always be done in the operating room followed by a frozen section. Such sections are satisfactory except on node lesions.

As to the use of electrical methods of excising biopsy material, anyone can think of situations in which they may be of value; for example, the abdomen is opened and nodules are found in the liver; is it Hodgkin's disease or is it carcinoma? The incising of such a tumor is not very satisfactory and electrical removal is preferable. The only objection to this technique is that it requires special apparatus. There is no advantage in it in general if the patient is under an anesthetic, and I do not like office biopsies. There is always a risk of a hemorrhage later.

If a carcinoma of the lip is to be treated with roentgen rays or radium, do a biopsy. If an operation is done there will be plenty of material for diagnosis and the rest can be preserved for final records. This preservation of material is highly important. There are a host of interesting examples of this. One, for instance, of a woman with a lesion of the gastric lymph nodes diagnosed as a metastasis from a carcinoma of the stomach, but the patient is now alive seven years later, so she did not have carcinoma of the stomach. However, the case has been reported as a case of carcinoma of the stomach cured by roentgen irradiation, of which she received heavy doses. But the material from which the diagnosis was made was used up in frozen sections and no permanent slide was kept. This patient has also been reported as a cancer cure from inhaling a mixture of carbon dioxide and oxygen. Later, however, this individual developed a tumor of the tonsil which was excised by a surgeon and it proved to be Hodgkin's or a related type of lymph tissue tumor, very sensitive to radiation. The cervical nodes disappeared promptly following irradiation, and the patient is now well. She probably had Hodgkin's disease of the stomach, which was cured by roentgen irradiation, and the carbon dioxide-oxygen inhalations were wholly ineffective.

So I demand and get well fixed material for my diagnoses and the slides and paraffin blocks are all kept for future record. Dr. Stewart's task is a different one. I would not recommend aspiration biopsy as a generally useful procedure. It is for the expert only, and they are few. I dislike endothermy material, for in New York it is almost always charred. But as a biopsy properly done is not dangerous, the method of taking it is unessential provided a correct diagnosis can be made.

DR. HUGH AUCHINCLOSS, New York City. This subject has interested me greatly and I was both glad and sorry to hear Dr. Wood talk about it.

One thing I think has not been stressed enough, and that is that there is a great deal of difference in selecting a method with a view to what the subsequent procedure is going to be. Whether one does a punch biopsy or incision, how long will it be before treatment is instituted? If one is prepared to start treatment immediately I think it makes very little difference what method is employed. If you biopsy tissues and then lock these injured tissues up you are doing precisely what Dr. McLean has done—you have transplanted the material, possibly activated it, and created additional

distributing foci of disease. This is theoretical but theory is necessary, for these statistics will not prove anything. One sees very surprising facts. The longest I have seen a case of cancer of the breast remain well was that of a woman who had the tumor removed the day before in the accident ward. If one uses the cautery knife you say the blood vessels are sealed and therefore there is no risk to the trauma. I cannot subscribe to that. If it stops bleeding that is fine. Indeed, it might keep the patient from bleeding to death. More has happened than merely the checking of hemorrhage. A number of cells have been destroyed, a number of lymphatics have been blocked, but when cancer itself blocks lymphatic channels, cancer cells then get distributed by circuitous and retrograde routes. We know that the same thing occurs in other conditions, notably in tuberculosis. Not only can retrograde metastasis be produced in the lymph channels leading from the tumor, but activation of the tumor is likely. The cautery may destroy and seal at one point, but exactly the opposite effect may be produced at a point just beyond where the electrocoagulation takes place. It is analogous to the way tubercle bacilli, for instance, may cause destruction in one area and hyperemia just outside it. During the reaction of repair, after a biopsy by punch, or knife, or cautery, if operation is delayed, that goes on for days and weeks and one is really paving the way for stimulating transmission of the disease to other parts of the body, either local or widespread. I think that this phase of the subject should be considered when we talk of any type of trauma to a malignant growth.

The method of punch biopsy is apt to be inadequate in breast surgery. The cancer is sometimes not the dominating, evident lump. Fluid may be sucked from a cyst, and a cancer near it overlooked. I have a clear recollection of a case which had a very evident cyst that stood out as a fluctuating spherical mass on the breast surface. When the incision was made, the blue dome was seen and the cyst opened. The finger was introduced and in the bottom of the cyst, just beginning to involve it, was a small but perfectly definite carcinoma. That was in a woman aged about thirty and within a few years she was dead with generalized metastases. I am afraid of these punch biopsies. In skilled hands they may often give valuable information and I am not questioning Dr. Stewart's ability to tell what he sees. I fear it lends a false confidence to those who use it and that some individuals will lose their lives because of the inadequacy of the method. I may state that in 4 or 5 cases of chest fluid aspirated by Dr. Stout for me from cases of cancer of the breast who developed pleural metastases, he has found the cancer cells and their subsequent course has demonstrated them to be carcinomatous.

When one speaks of closing blood vessels by the endothermy method is that just what is wanted? I am not so sure that it is. It is quite possible that if one is prepared to do an immediate radical operation it is best not to close those blood vessels, but to allow the blood and lymph to come out into the wound rather than to be backed up in the system. We do not know how long it takes to have cancer cells disseminate through the lymph channels. Everyone has had the experience of injecting novocaine and adrenalin into a finger and seeing it very rapidly run up the arm. I think punch biopsies should be limited to very specific cases where the advantages are obvious. In the needling of the liver I wish to offer a word of caution. I have needled two livers for abscesses with fatal hemorrhage. I have known of others. It is safer to make a little oblique or transverse incision and see the liver, if it is under suspicion, before doing a radical mastectomy. If a specimen is cut from the liver, bleeding can be checked by filling the defect with a piece of rectus or oblique muscle.

I think a punch biopsy should be used only very exceptionally, as, for instance, to secure specimens for study in inoperable cases. Most cases of cancer of the breast require no biopsy. In doubtful cases aspiration and punch methods may be inadequate. No one should be content with an inadequate method. One should make sure.

Dr. Frank E. Adair, New York City. I think the essayists should be congratulated, and I am quite surprised that it was a bloodless afternoon. They are defending their position very ably, but I think the men who discussed the papers brought out the main feature, and that is that each procedure has its own particular usefulness. In incisional biopsy we all go into the breast, but so many other occasions arise when you are suspicious that metastasis to the spine exists, and this has persisted. The genitourinary specialist says he is not sure. Time and time again I have seen that demonstrated by a simple procedure that took five minutes to tell that it was cancer we were

dealing with. In many of the breast tumors if you are going to give preoperative irradiation, and certainly the tendency today is to do this, for in the average case in America cure is only 35 per cent and we have to do something to step this up, you cannot do an incisional biopsy and then give enough preoperative irradiation. I can see many advantages in the endothermy method reported by Dr. Ward. I think the aspiration biopsy has come to stay and believe that in five years we will use it far more than we do today.

DR. R. E. FRICKE, Rochester, Minn. The importance of this symposium cannot be overestimated. Tissue removed for microscopic study from living subjects by any method should help establish the diagnosis, advance our knowledge of malignant disease in general, and should also aid in formulating a plan of treatment in the individual case. Obviously, the average patient coming to the therapeutic radiologist today is in the advanced stage of the disease. Clinically, the ulcerating necrotic surface cannot be mistaken. With adequate treatment, in many cases the local lesion may heal and the patient may be well for five or ten years. If biopsy has not been made there is always a question about the original diagnosis.

Three methods for taking biopsies have been described. We might add the ordinary biopsy, made with a cutting or crushing instrument. The size of the piece of tissue taken is about that of a grain of wheat. An important point is to secure characteristic tissue. If only necrotic tissue is removed, the pathologic report will usually read "very inflammatory tissue." At the time, such a report may seem unimportant. Should the patient survive, however, the true status of the primary lesion may be very important and may assume a medicolegal aspect.

Radiologists should become biopsy-minded or tissue-minded in that they should see to it that the cases are properly studied and that the correct diagnosis is reported before treatment is instituted, not only for all present purposes, but for future purposes of advancing our knowledge of this dread disease.

DR. ROBERT B. GREENOUGH, Boston. The result of this meeting demonstrates, I think, what I hoped would happen, in that it has been made clear to this audience, as it has not always been made clear to other audiences, and in papers which have been published, that there are several different methods of accomplishing an object, each of which may be excellent in its place and that some one of these methods may be appropriate in one situation and others, in another. Each of the three methods should be at the command of the radiologist or the surgeon who is dealing with cancer and he should select the best method to be applied to the individual case with which he comes in contact. It takes us a long time to reach the point in medicine and surgery where we realize that there may be several different methods of accomplishing a purpose, one of which may be suitable for one case and another for another. We easily become partisans in advocating one method over another, especially if we have ourselves had a hand in the development of that method. We have all come to feel, for instance, that the electrosurgical apparatus has a definite place in surgery but there was much opposition to this in the beginning because the men who were interested in developing it appeared to advocate its use in all operations rather than in the ones in which its use was especially appropriate. It has been shown that this technique is *not* applicable to all operations but is of nevertheless great value in others. I suppose this is true in all branches of medicine.

There is one point I would like to make and that is that biopsy may be needed for several different purposes. In some instances a biopsy is needed just as much to show that a person has not got cancer as to show that there is cancer. In some of the extensively diseased breasts, such as Dr Auchincloss referred to, where the gland is diffusely diseased with apparently benign lesions, operation may be performed under the idea that it is a benign condition of the breast. When the breast has been removed, however, and is sectioned carefully, evidence of cancer may be found. Such a case needs widespread gross inspection by multiple incisions to determine whether cancer is present or not. I mention this as an example of the necessity of having a biopsy to show the other side of the picture. We must admit, of course, that a negative aspiration biopsy cannot be considered of any value at all. The technical difficulties of the aspiration biopsy which include the difficulty of placing the needle at the precise point desired, as well as the great skill and experience needed for the correct pathological examination of these minute specimens, must limit somewhat the general adoption of the aspiration method.

RADIUM IN PRIMARY CARCINOMA OF THE FEMALE URETHRA*

By LAWRENCE A. POMEROY, M.D., F.A.C.S.
CLEVELAND, OHIO

PRIMARY carcinoma of the female urethra is probably not so rare as it is usually thought to be. During the past fifteen years I have observed 7 cases, the diagnosis in every instance having been confirmed by microscopic examination of a biopsy specimen. Five of these cases have already been reported.[9,10,11] Of these 5 patients one woman, who was treated over twelve years ago (April, 1923), is now alive with no symptoms or signs of recurrence of the tumor.

I wish to report the 2 most recent cases and to describe the technique used in their treatment.

CASE 1. Mrs. E. P., aged sixty-nine. This woman entered Lakeside Hospital on May 8, 1933, complaining of frequent and painful urination of three months' duration. Her past history was negative except for the presence of a goiter for the past thirty-five years for which she had received some medical treatment. She had borne two children with no history of puerperal lacerations or pelvic infections. A biopsy performed twelve days previously at another hospital showed a squamous cell carcinoma of the urethra.

FIG. 1. Case 1. Carcinoma of the urethra.

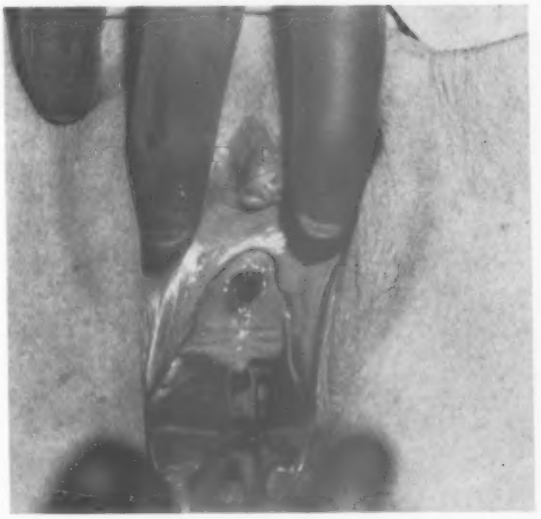

FIG. 2. Case 1. Carcinoma of the urethra.

Local examination showed a slightly relaxed vaginal outlet. Inspection revealed a red hemispherical swelling at the external urinary meatus, the mucosa being smooth and not ulcerated. Palpation revealed a firm globular mass 2 cm. in diameter involving the urinary meatus and the posterior and lateral urethral walls. The inguinal nodes on both sides were small, discrete, and firm. For the purpose of treatment this growth was considered as a sphere 3 cm. in diameter, thus including the visible and palpable tumor and a margin of apparently normal tissue. Into this sphere 8 gold implants with a wall thickness of 0.3 mm. and a radon content of 2 mc. were inserted. This made a dosage of $8 \times 2 \times 132$ equals 2,112 mc-hr., or a dosage of eight skin erythema doses to a sphere 3 cm. in diameter. A retention catheter was not inserted through the urethra.

Roentgen irradiation of the inguinal nodes was commenced during the patient's stay in the hospital.

On December 13, 1934, nineteen months after treatment, a urologist, who had recently examined the patient, reported complete local healing with no palpable enlargement of the inguinal lymph nodes.

* From the Departments of Radium Therapy, City, Lakeside, and St. Alexis Hospitals. Read at the Twentieth Annual Meeting, American Radium Society, Atlantic City, N. J., June 10–11, 1935.

Fig. 3. Case I. Squamous cell carcinoma of the urethra—low power.

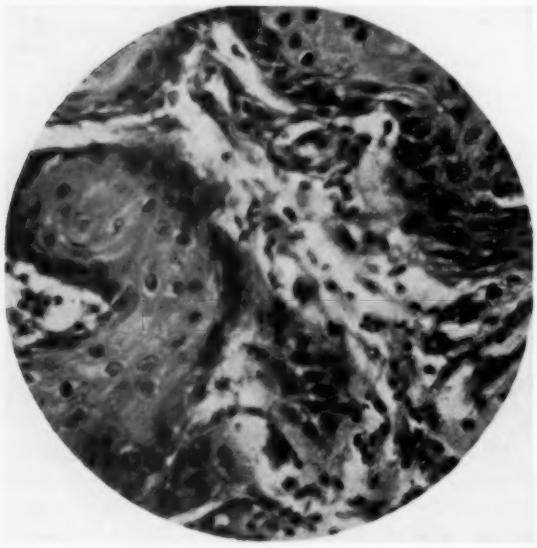

Fig. 4. Case I. Squamous cell carcinoma of the urethra—high power.

Case II. Mrs. C. H., aged forty. This patient was seen on August 30, 1934. She complained of a slight discharge of blood from the region of the external urinary meatus. This was first noted two and a half years before, about four months after the birth of her second child. At times there had been slight local tenderness. Her past history was negative except that for two years, between the ages of fourteen and sixteen, she suffered from some bladder infection which was treated by irrigations. The birth of her first child had been normal but the second child was delivered with instruments, there probably being some lacerations at this time. There was no history of pelvic infection.

On August 21, 1934, her surgeon excised what appeared to be a urethral caruncle, a sessile growth about 8 mm. in diameter occupying the posterior margin of the external meatus. Microscopic examination showed a squamous cell carcinoma with very little differentiation. On August 30 examination showed a semicircular area of induration 1 cm. in length, curving so as to follow the posterior half of the urethral opening. The line of incision was well healed but there was induration 5 mm. thick and 7 mm. wide. There were no nodes palpable in the inguinal or femoral regions.

On August 31 radium element needles, each

Fig. 5. Case II. Carcinoma of the urethra.

Fig. 6. Case II. Carcinoma of the urethra.

with a content of 1 mg. and a wall thickness of 0.5 mm. platinum, were inserted into this remnant of the growth. Four such needles were inserted in two pairs, the needles of each pair being tied together. These needles remained in position five days, making a dosage of $4 \times 24 \times 5$ equals 480 mg-hr. A retention catheter was kept in the urethra while the needles were in place.

Roentgen irradiation of the regional nodes was not employed in this case, the patient being kept under close observation.

The patient was last seen on April 6, 1935, seven months after treatment. At this time there were no symptoms or signs of recurrence of the growth. The inguinal and femoral nodes were not palpable.

The possibility of secondary malignant tumors in the region of the external urethral meatus should be kept in mind. Willis,[15] in his excellent book on the subject of secondary tumors, mentions the possibility of a carcinoma of the kidney (especially the left kidney) metastasizing to this region by retrograde venous embolism.

Among recent publications on carcinoma of the female urethra are articles by Counseller and Paterson,[1] Delporte and Cahen,[2] Menville and Counseller,[4] Mercier and Grenier,[5] Ottow,[7] Phillips and Douglass,[8] Stephan,[13] and Wilkinson and Judd.[14]

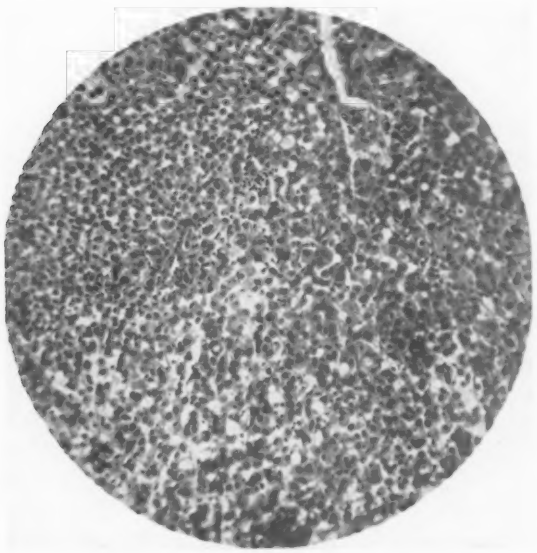

Fig. 7. Case 11. Squamous cell carcinoma of the urethra—low power.

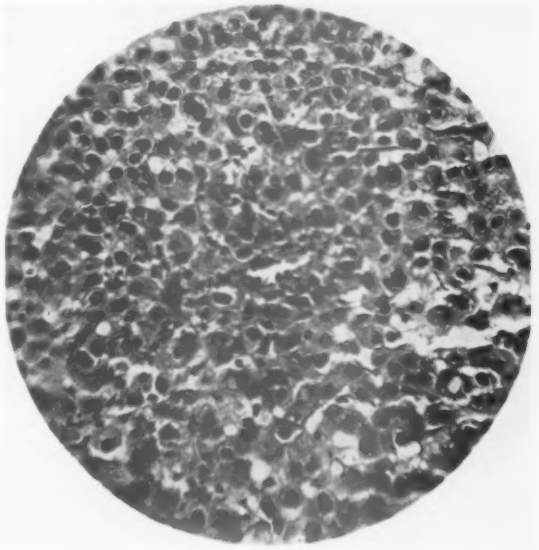

Fig. 8. Case 11. Squamous cell carcinoma of the urethra—high power.

Eichenberg[3] and Müller[6] report instances of this tumor in pregnant women. Schweigl[12] suggests ureteral transplantation in advanced carcinoma of the urethra.

SUMMARY

Interstitial irradiation, using either gold radon implants or removable platinum needles containing radium element, is a satisfactory method of treating the local tumor of the urethra. In the two most recent cases complete regression of the tumor was obtained and the lumen of the urethra preserved. The treatment of the regional lymph nodes presents a problem fully as important as the problem presented by the local lesion. If the local tumor disappears under irradiation the lymph nodes may be treated by surgical excision or by irradiation. Occasionally, as in the second case reported, nodes that are not palpable may be kept under close observation and no treatment employed unless definite enlargement is detected.

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DISCUSSION

DR. WILLIAM P. HEALY, New York City. I wish to comment on one item of Dr. Pomeroy's presentation, and that is the late possible recurrence of carcinoma about the urethral orifice from the primary carcinoma of the cervix. In general, our experience in those cases has been that they do not recur close to the urethral orifice but within the hymenal ring. You all know we saw them frequently when we were doing hysterectomies for cancer of the cervix but they were always at the introitus rather than at the external meatus. It may be of interest therefore to state that we have now at the Memorial Hospital a negress who was treated by us fourteen years ago for advanced carcinoma of the cervix with radium. She has remained perfectly well until within the last two or three months. Then she developed some distress in the region of the vulva and came in about ten days ago with a lesion the size of an olive at the urethral orifice, which was extremely hard. We made a diagnosis of papilloma, did a biopsy and it was reported papilloma. We removed the lesion with the cutting current and the pathologist then reported squamous cell carcinoma. I do not believe that it is in any sense of the word a metastatic recurrent carcinoma from the primary carcinoma of the cervix fourteen years ago. I believe it is a second primary tumor for we know that many of these patients who develop carcinoma have multiple primary carcinomata. We will treat this lesion as Dr. Pomeroy treated his, and as we have treated cases similar to his occurring at the external meatus. We have usually regarded these as ordinary vulvar carcinoma rather than urethral, because the lesions seem a little more pronounced on the vulvar surface than on the urethral, and we have treated them with radiation therapy. On the whole, the results I think have been satisfactory. The group is small but they do respond to interstitial irradiation and I think that is the proper method of treatment.

I was interested in Dr. Pomeroy's statement that in the first case he reported he used roentgen irradiation of the lesion in the groin. I think it would be interesting to know the amount of radiation he gave with roentgen ray, and whether he finds this efficient in treating metastases in the groin from either the urethra or the vulva.

DR. POMEROY (closing). The roentgen treatment was given according to the old technique which is not in use at the present time. The equivalent of 350 r was given twice over each groin at intervals of about three days, the factors being 200 kv., 50 ma., 50 cm. distance, filter 0.5 mm. Cu plus 1 mm. Al, time 10 minutes.

The nodes in both groins were palpable at the time of treatment and later disappeared. I presume they were not involved by the malignant disease.

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Research and Standardization Committee: Maurice Lenz, Chairman, New York City, Wilhelm Stenstrom, Minneapolis, Minn., L. R. Sante, St. Louis, Mo.

Education and Publicity Committee: G. E. Pfahler, Chairman, Philadelphia, Pa., H. H. Bowing, Rochester, Minn., Henry Schmitz, Chicago, Ill.

Advisory Committee on Roentgen-ray and Radium Protection: J. J. Duffy, Chairman, New York City, J. L. Weatherwax, Philadelphia, Pa., W. H. Cameron, New York City.

Janeway Lecture Committee: Douglas Quick, Chairman, New York City.

Committee on Arrangements: E. H. Skinner, Chairman, Kansas City, Mo., E. K. Robinson, Kansas City, Mo., W. R. Brooksher, Fort Smith, Ark.

Twenty-first Annual Meeting: Kansas City, Mo., May 11–12, 1936.

EDITORIALS

SYPHILITIC AORTITIS

THE steadily declining death rate from pulmonary tuberculosis can be attributed to the following three causes: the intensive educational campaign that has been conducted throughout the country by health departments and by the various organizations having to do with the care and treatment of the tuberculous patient, and the diagnostic and therapeutic measures which have been instituted in detecting and treating both the early and advanced cases of tuberculosis. In the realm of diagnostic procedures may be placed, first, the roentgen-ray examination, and roentgenologists may be justly proud of the part that they have played not only in the dissemination of the knowledge of the aid which the roentgen examination gives in the diagnosis but also in the information which it discloses as to the best therapeutic measures to be instituted. So it may be safely said that without the roentgen examination the steadily declining death rate from pulmonary tuberculosis would hardly be possible.

It is unfortunate that the same degree of intensive roentgen study of the cardiovascular diseases has not been employed. This in spite of the fact that many articles dealing with the subject have appeared from time to time both in the roentgenologic literature and in the journals devoted more particularly to the diseases of the heart and aorta. Sproull[1] in a comprehensive paper read before the annual meeting of the American Roentgen Ray Society in Atlantic City in 1931 called attention again to the importance of the clinical application of roentgenology in studies of the thoracic aorta. He said that patients with symptoms suggesting disease of the circulatory system are not referred for roentgen examination in any such percentage as are patients with symptoms suggesting disease of either the gastrointestinal or respiratory tracts. It is Sproull's opinion that the roentgen examination is an essential in the diagnosis of aortic disease and that without its aid a large percentage of the cases of aortic disease will pass unrecognized. He pointed out that roentgen examination of the aorta is not barren in results, as its infrequency might suggest. On the contrary, it is markedly efficient in showing definite aortic pathology not discoverable by other methods of examination, and it is also valuable in a negative sense by excluding aortic disease as a cause of intrathoracic or cardiac symptoms simulating those of disease of the aorta.

Syphilitic aortitis is not of such rare occurrence as to justify the present attitude of indifference toward its detection. No better proof of this can be cited than a recent paper by Maynard[2] and his associates on cardiovascular syphilis, early diagnosis and clinical course of aortitis in 346 cases of syphilis. In this report the investigators were primarily interested in the early diagnosis of aortitis and were particularly anxious to establish a criterion for the diagnosis of aortitis uncomplicated by aortic insufficiency or aortic aneurysm, and as they say, they were "aware of the existence of a considerable body of competent opinion which holds that, in the absence of aneurysm or gross abnormality of the aorta, it is not safe to make a positive diagnosis of syphilitic aortitis before the

[1] Sproull, John. Status and clinical application of roentgenology of the thoracic aorta. *Am. J. Roentgenol. & Rad. Therapy*, 1932, *28*, 37–48.

[2] Maynard, E. P. Jr., Curran, J. A., Rosen, I. T., Williamson, M. D., and Lingg, Claire. Cardiovascular syphilis; early diagnosis and clinical course of aortitis in three hundred and forty-six cases of syphilis. *Arch. Int. Med.*, 1935, *55*, 873–894.

appearance of aortic insufficiency." In spite of this somewhat pessimistic attitude toward the diagnosis of syphilitic aortitis which is generally held, they were able to prove by a critical study of their cases that by a roentgenoscopic and roentgenographic examination of the chest they could establish a diagnosis of aortitis. In arriving at this diagnosis they employed a technique which should be familiar to all roentgenologists, namely, exposure of the patient's chest at a two meter distance in the usual posteroanterior position and also in the left anterior oblique view, supplementing this examination by a roentgenoscopic study. In their classification of patients all aortas measuring seven centimeters or more were classified as dilated; particular reliance was placed on the contour of the ascending aorta and arch, special attention being given to bulging of the ascending aorta. In arriving at their diagnosis of syphilitic aortitis in the absence of aortic insufficiency or aneurysm, they excluded other clinical conditions in which the aorta is dilated, namely, arterial hypertension, arteriosclerosis and aortic regurgitation of rheumatic origin, and in determining the measurements of the vascular stripe they excluded those cases with high diaphragm and those with a scoliosis which tended to deform the vascular stripe.

In an analysis of their 346 cases with syphilis, 145, or 41.9 per cent, showed positive evidence of cardiovascular syphilis. The date of occurrence of the primary lesion was known in a little more than half the patients, or 55 per cent. The average age at which infection occurred was twenty-six years. In a quarter of the patients studied the chancre appeared before the age of twenty-one. One-fourth of their total number of cases came for examination within one year, and one-half within ten years after the occurrence of the initial lesion. Evidence of cardiovascular syphilis was found within ten years after the appearance of the chancre in one-fourth of the cases, although the average interval from infection to discovery of heart disease was twenty years. Evidence of cardiovascular syphilis was found within the first three years after the appearance of the chancre in eight patients.

From a critical analysis of their cases they came to the conclusion that syphilis of the aorta can now be recognized much earlier than in the past, but in order to discover its presence it is necessary to have every syphilitic patient examined regularly by methods used in making a diagnosis of cardiovascular disease, that these examinations be repeated once in six months or once a year, and that roentgenography and roentgenoscopy provide the most reliable means of deciding whether abnormality of the aorta is present in early syphilis. They also concluded that it is probably not true that syphilitic aortitis is a late lesion occurring, on the average, twenty years after the occurrence of the chancre. Their study showed that involvement of the aorta begins soon after the chancre has appeared and that, in the past, discovery of the presence of the disease has been delayed by late development of symptoms referable to the heart and more especially by inadequate methods of examination. If one places his reliance solely upon the Wassermann examination many of these early cases will be missed, as Elliott[3] places the margin of error of the negative blood Wassermann reaction in syphilitic vascular disease as high as 40 per cent. That syphilitic aortitis is a very prevalent disease cannot be questioned. The importance of its early recognition cannot be too strongly emphasized and the part that the roentgen ray may play in its early detection has been fully pointed out by many observers, but unfortunately this has not been made adequate use of by roentgenologists, and as Sproull says "the omission commonly to employ a method of examination, which is almost universally approved, as a valuable aid in the diagnosis of what is conceded to be a group of common pathological conditions, is unjustifiable negligence, and educational efforts should be promoted to correct it."

[3] Quoted by Sproull.

CLASSIFICATION OF PHYSIOLOGIC OR PATHOLOGIC EFFECTS OF IRRADIATION
(ROENTGEN RAYS OR RADIUM)

IN FEBRUARY, 1935, Dr. L. Reynolds, Editor of the AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY wrote to the Chairman of the Committee on Safety and Standards to bring to his attention a communication from Dr. U. V. Portmann, of the Cleveland Clinic, concerning the desirability of a classification of "damages due to x-ray and radiation." Among the reasons for such a classification, one is that, as Dr. Portmann pointed out, various bodies who have prepared some classified nomenclature of diseases have undertaken, apparently without benefit of special experience or advice, to include in their classification such an inadequate and misleading heading as "X-ray burns."

As soon as the Committee on Safety and Standards began to consider the question thus presented, its members at once realized that an attempt to classify the physiologic and pathologic effects of exposure to roentgen rays or radium had never before been made. The numerous phases of the problem required prolonged and careful consideration. It was obvious that an adequate classification should include all the effects of irradiation, as these are encountered in the practice of medical radiology, but at the same time should avoid misleading terms. In preparing the classification which it now submits the Committee on Safety and Standards realizes that, despite all its efforts, errors of commission or omission may have been made. Such errors will be corrected as soon as their existence is known. Also, no doubt, amendments or additions may have to be made from time to time as knowledge increases. However, it is the hope of the Committee that this first attempt to classify the effects of roentgen and radium irradiation may prove reasonably satisfactory.

T. LEUCUTIA
F. J. HODGES
H. K. PANCOAST
G. E. RICHARDS
W. D. COOLIDGE
A. U. DESJARDINS, Chairman

Committee on Safety and Standards, American Roentgen Ray Society.

I. Systemic Reaction
- General: anorexia, nausea, vomiting, general weakness
- Blood: temporary leukopenia; anemia—aplastic; anemia—pernicious or other forms
- Gastrointestinal tract
  - Enteritis: acute, with diarrhea; chronic, with diarrhea followed by obstructive phenomena from organic effects on intestine
  - Colitis: acute; chronic
  - Proctitis: acute; chronic

II. Effects on Skin and Mucosa
- Early
  - Epilation (alopecia radiologica): temporary; permanent
  - Atrophy
  - Dermatitis, acute (roentgen rays or radium)—first degree (erythema—cutaneous hyperemia, exfoliation of epidermis, and slight pigmentation)
  - Dermatitis, acute (roentgen rays or radium)—second degree (erythema—cutaneous hyperemia, edema, vesicle formation, and moderate pigmentation)
  - Dermatitis, acute (roentgen rays or radium)—third degree (erythema—cutaneous hyperemia, edema, focal ulceration, marked pigmentation and scar formation)

Massive ulceration (necrosis) of irradiated areas
Brawny induration of skin and subcutaneous, areolar tissue (without ulceration of skin)
Brawny induration of skin and subcutaneous tissue, with adhesion of muscles (without ulceration of skin)
Epidermitis from protracted, fractional irradiation
Late
Telangiectasis
Dermatitis, chronic (roentgen rays or radium)
with early necrosis of tissue
with late necrosis of tissue
with focal hypertrophy of skin
with epitheliomatous transformation
Mucous Membranes
Epithelitis from protracted, fractional irradiation

III. Effects on Deep Tissues and Organs
Salivary glands
Acute mucoid ptyalitis
Chronic hypoptyalism (causing dryness of mouth and throat)
Larynx: acute laryngitis with edema of glottis
chronic
laryngitis: with perichondritis
without perichondritis
Lungs and pleura: acute pneumonitis with edema and/or hydrothorax
chronic fibrous pneumonitis
Urinary tract: acute nephritis
chronic nephritis
acute cystitis
chronic cystitis
Genital glands
Testis: temporary azoospermia
chronic azoospermia
Ovary: temporary arrest of menstruation
permanent arrest of menstruation
Fetus (abortion)
Liver (chronic cirrhosis)
Other chiefly late effects
Muscles (retarded growth)
Bone: retarded growth
abnormal repair
devitalization of bone (osteoporosis)
Eye: conjunctivitis
degeneration of crystalline lens (cataract)

BUNDY ALLEN
1885-1935

BUNDY ALLEN was born in Carbondale, Illinois, August 21, 1885, the son of W. W., and Letha Stewart Allen. He was educated in the Carbondale public schools and had his pre-medical work at the University of Indiana. He graduated in medicine in 1912 at the St. Louis University, St. Louis, Missouri. After his internship he was located for two years in Keokuk, Iowa, where he was engaged in laboratory and roentgenological work. In 1915 he moved to Iowa City and from that time until March 15, 1926, was head of the roentgen department of the Hospital in connection with the Medical Department of the State University. In 1926 Dr. Allen

moved to Tampa and formed a partnership with Dr. J. C. Dickinson, which association was continued to the date of his death. On December 23, 1912, he was married to Edith Cochenour of Nevada, Missouri, who with a son, Joe Bundy Allen, aged eleven, survives him.

Dr. Allen was a member of the American Medical, Florida State and Hillsborough County Medical Associations; the Radiological Society of North America; the American Roentgen Ray Society; the American Radium Society; the American College of Radiology; the British Institute of Radiology. He was President of the Radiological Society of North America in 1931. Locally he was a member of the Rotary Club, various Masonic bodies, and the First Presbyterian Church. He was an enthusiastic sportsman and took a great deal of pleasure in acquiring antique and modern firearms of which he had an elaborate collection.

Bundy Allen was genial, generous, loyal, big-hearted—always taking a leading part in things medical, an expert radiologist, a well-informed teacher and organizer of ability, a capable executive.

As President of the Radiological Society of North America all these qualities were well exhibited. His program was really a well-organized congress of radiology. The only criticism one heard about it was there was too much good material in it to digest. Bundy Allen worked hard for that meeting and made it a great scientific success. He showed his loyalty to his adopted State—Florida—and his appreciation of the honor of the office of President that was given him, by putting on an unusual exhibit for radiologists, namely, one of oranges from Florida. He distributed a carload of these among those attending the meeting.

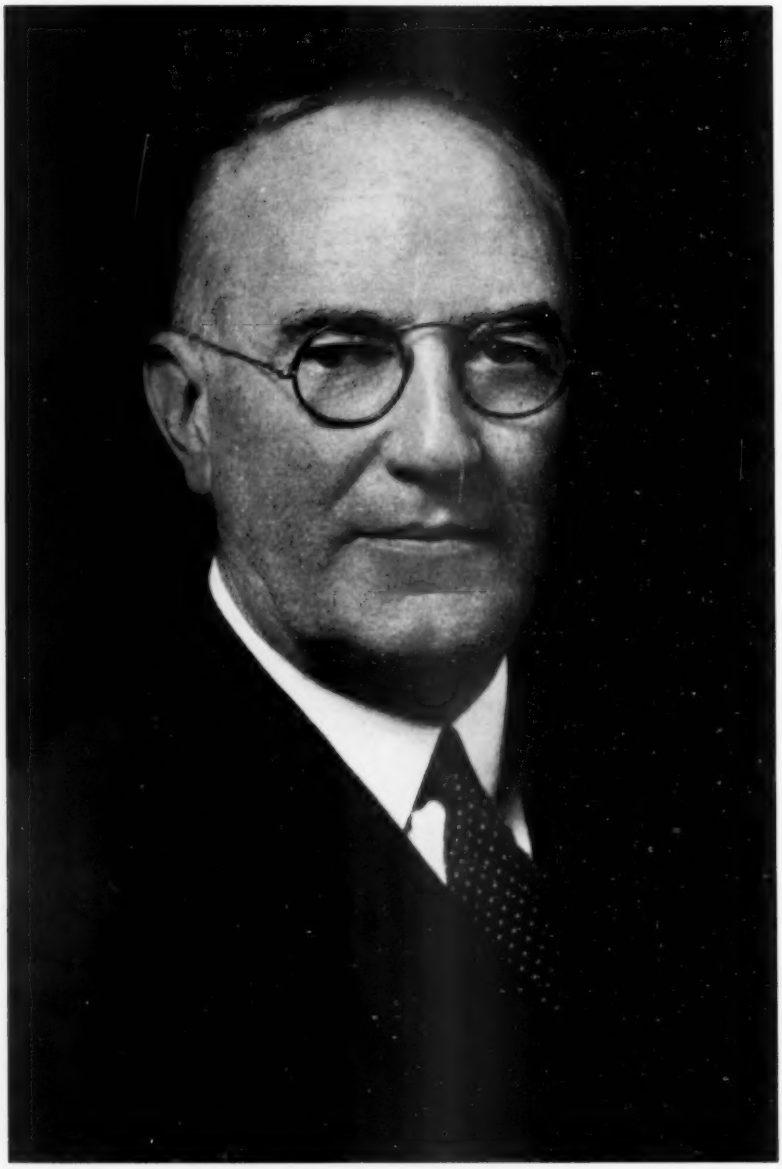
As Associate Editor of *Radiology* he did much to elevate the standard of that Journal. He was not a prolific writer, but what he did write was well worth the reading.

As a member of the Radiological Society (without portfolio) or, as an officer, he was always ready to do his duty and did it regardless of consequences. He never boasted of his accomplishments. He did his work quietly, honestly, thoroughly, without ostentation. He could play as well as work. He made friends wherever he went and generously shared his pleasures with them.

To know Bundy Allen was to know a true and loyal friend. I never knew a more congenial and happy partnership than that with his friend, J. C. Dickinson, with whom he was associated many years in Tampa. They were both apparently quite independent of each other, yet most cooperative and helpful in working out the many intricate problems met with in their practice.

Radiology, in particular, and medicine, in general, have lost a constant and constructive exponent in Bundy Allen, cut off so suddenly in his prime.

Rollin H. Stevens



WILLIAM L. CLARK
1876-1936

DR. WILLIAM L. CLARK of Philadelphia, distinguished pioneer of electrosurgery, died of biliary disease at his home, on January 12, 1936, after an illness of three months. Dr. Clark was born at Honesdale, Wayne County, Pennsylvania, July 30, 1876, son of Mr. and Mrs. Edward C. Clark. He was a descendant of an old Colonial family.

His early education was obtained in the Honesdale schools, where he taught for several years after graduation. Pursuing his ambition to study medicine, he entered Niagara University, and later matriculated

at the University of Pennsylvania Medical School, from which he received his degree in 1903. His internship was served at St. Joseph's Hospital, following which he entered upon private practice.

He was very active in writing and presented numerous papers on the use of the electrothermic method. He was always anxious to teach others the technique, and was never happier than when demonstrating it to a group of physicians. It was quickly taken up by others and its use has spread throughout the world. His contributions to medical literature have appeared in the foremost medical journals, not only of this country, but abroad. He contributed a chapter on electrosurgery to Da Costa's Textbook on Surgery; a chapter on electrosurgical methods to the Principles and Practice of Physical Therapy by Mock; and one on the same subject to the System of Surgery by W. W. Keen.

In 1923, Dr. Clark opened a private hospital at 23rd and Walnut Sts., Philadelphia, for the treatment of malignant disease. As a pioneer in the use of radium and roentgen rays, he was one of the first to use the divided dose technique in roentgen therapy and never departed from this, even in the days when massive doses of roentgen rays were in vogue.

He was one of the leaders in physical medicine and surgery, and has been honored by the presidency of the American Physical Therapy Association, the American Congress of Physical Therapy and the American Academy of Physical Medicine. In 1933, he was presented with the Gold Key of the American Congress of Physical Therapy and had the honorary degree of Fellow of the American Academy of Physical Medicine conferred upon him by that organization. He was a Fellow of the American Medical Association, a member of the Pennsylvania State Medical Society, Philadelphia County Medical Society, Philadelphia Medical Club, American Radium Society, and the Philadelphia Dermatological Society.

Dr. Clark was at one time on the staff of the St. Agnes Hospital, St. Mary's Hospital and Jefferson Hospital. He was lecturer on physical therapy at Jefferson Medical College for a number of years.

Dr. Clark's contribution to medicine and surgery obtained for him a foremost position, not only in the United States, but abroad. His determination to complete an undertaking once started, in a large measure accounts for his success. His outstanding ability as a teacher was evidenced by the interest displayed by the students in the medical school, and by the eagerness with which his fellow practitioners sought knowledge at his feet. His personality and courtesy were such that all who sought, received abundantly of his knowledge. His influence on the development of physical therapy was inestimable and his perfection of the electrothermic method has been one of the great advances in surgery in modern times. His host of friends and patients lament his passing.

He is survived by his widow, Mary McMahon, four sons, David, William L. Jr., Edward, Robert, and two daughters, Nancy and Margaret.

William H. Schmidt

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. E. P. Pendergrass, University Hospital, Philadelphia, Pa. Annual Meeting: Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Dr. B. H. Orndoff, 2561 N. Clark Street, Chicago, Ill. Annual meeting: Kansas City, Mo., 1936.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: Kansas City, Mo., May 11–15, 1936.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N.Y. Annual meeting, 1936: To be announced.

RADIOLOGICAL SECTION, BALTIMORE CITY MEDICAL SOCIETY
Secretary, Dr. W. B. Firor, 1100 N. Charles St., Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT STATE MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets annually in May. Special meetings may be called by the Chairman.

RADIOLOGICAL SECTION, LOS ANGELES COUNTY MEDICAL SOCIETY
Secretary, E. N. Liljedahl, Los Angeles, Calif. Meets on the second Wednesday of each month at the County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas. Annual meeting, Baltimore, Md., Nov. 17–20, 1936.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. H. G. Reineke, General Hospital Cincinnati, Ohio. Meets third Monday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, North W. Shetter, M.D., 14600 Detroit Ave. Meetings are held at 6:30 P.M. at the Cleveland Chamber of Commerce Club rooms on the fourth Monday of each month from October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. K. D. A. Allen, 452 Metropolitan Building, Denver, Colorado. Meets on any month having a fifth Monday.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne Country Medical Society Building.

FLORIDA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. Gerard Raap, Miami, Florida. Meetings held twice a year, May and November.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. H. W. Grote, 219 N. Main St., Bloomington, Ill. Regular meetings held quarterly.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. J. N. Collins, Indianapolis, Ind. Meeting held the second Sunday in May annually.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. M. Dannenberg, 1464 Eastern Parkway, Brooklyn, N. Y. Meets on third Thursday of each month from October to May, at 8:30 P.M.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. S. W. Donaldson, St. Joseph's Mercy Hospital, Ann Arbor, Mich. Three meetings a year, Fall, Winter, and Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting designed by the president.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. L. G. Rigler, University Hospital, Minneapolis, Minn. Meets in St. Paul, Minn., in March, 1936.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. Thomas R. Healy, 370 Marlboro St., Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. P. S. Avery, New Brunswick, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. E. F. Merrill, 30 W. 59th St., New York. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse, N. Y. Three meetings a year—January, May, and November.

PACIFIC ROENTGEN CLUB
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, Williamsport, Pa. Next annual meeting June 5 and 6, 1936, Lycoming Hotel, Williamsport, Pa.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. Thomas Loughery, Germantown Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. W. W. Fray, Strong Memorial Hospital. Meets monthly on second Thursday from October to May, inclusive, at 7:45 at the Rochester Medical Association Building.

ST. LOUIS ROENTGEN RAY SOCIETY
Secretary, Dr. P. C. Schnoebelen, Missouri Bldg., St. Louis, Mo. Meets first week of each month. Time and place of meetings designated by president.

SOUTH CAROLINA X-RAY SOCIETY
Secretary, Dr. R. B. Taft, 105 Rutledge Ave., Charleston Meets at time and place of South Carolina State Medical Association.

TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary-Treasurer, Dr. J. H. Smith, Lubbock, Texas.
Meets annually one day preceding the meeting of the Texas State Medical Association.

University of Michigan Department of Roentgenology Staff Meeting
Secretary, Dr. C. B. Peirce, University Hospital, Ann Arbor, Mich.
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Roentgen Club
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis.
Meets monthly on last Thursday, October to April, Service Memorial Institute, at 4:30 P.M.

Virginia Roentgen Ray Club
Secretary, Dr. V. W. Archer, University Hospital, University, Va.
Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Electro-Therapeutic Section of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

Section on Radiology, Canadian Medical Association
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale.
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, II.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgengesellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

Societa Italiana Radiologia Medica
Secretary, Professor M. Ponzio, University of Turin, Turin.

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Virgil Ionescu, B-dul Schitu Măgureanu 49, Bucarest.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan. Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime.

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6.30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

ASSOCIATION OF GERMAN ROENTGENOLOGISTS AND RADIOLOGISTS OF THE CZECHOSLOVAKIAN REPUBLIC*

The thirteenth meeting of the Association of German Roentgenologists and Radiologists of the Czechoslovakian Republic was held in Prague on October 26 and 27, 1935.

The number of papers as well as the attendance at this meeting has so increased in the last few years that a fourth session had to be added to the usual three scientific sessions. Also, the exhibits at the meeting had to be given much more space. After the addresses of the official delegates and the delegates of the associated societies Herrnheiser (Prague) delivered an address to the honorary president, Jaksch-Wartenhorst (Prague) in which he conveyed the congratulations of the society on his eightieth birthday. He emphasized the particular service which the celebrant had given to the development of roentgenology and emphasized especially the fact that Jaksch-Wartenhorst was the first to recommend the use of metal filter in roentgen diagnosis, a procedure now so obviously the correct one, but which was violently attacked when he proposed it. The Association decided to establish a fund in honor of Jaksch-Wartenhorst which would serve principally to furnish prizes for the work of young roentgenologists or for their encouragement.

Diagnosis. The first day was devoted to diagnosis, and in this session Schwarz (Vienna) began with a report on the present status of roentgen diagnosis of diseases of the large intestine. In regard to technique he emphasized the importance of repeated examination, and he prefers complete filling, the results of which are much more conclusive than those of partial filling. He recommends investigation with the patient supine, and, to bring out the genu rectoromanum and the sigmoid, rotation of the patient from left to right. In the clinical portion he emphasized particularly the question of recognition of cancer of the colon and its differential diagnosis from other pathologic processes.

Fried (Karlsbad) and Neuschul (Prague) recommend for the demonstration of the relief of the large intestine the addition of a powder, commercially obtainable under the name of liquibar, by which the barium sulphate is put in suspension in the water so that it does not precipitate. In the discussion Reiser (Prague) recommended for demonstration of the sigmoid and the ampulla the prone position. Eisler (Vienna) advised the use of a balloon on the end of the enema tip rather than the use of the long thin catheter. Herrnheiser (Prague) and Herzog (Witkowitz) emphasized the value of demonstration of the relief.

Stumpf (Munich) reported his experiences with surface kymography of the stomach with special reference to the study to the speed of the waves and the mucosal movements and came to the conclusion that the objective presentation of peristaltic movements by surface kymography may add definite information to that obtained by roentgenoscopy. Eisler (Vienna) concluded from his studies that thickening of the mucous membrane does not always mean gastritis, and he advised in those cases where a diagnosis of gastritis has been made from a clinical point of view an extensive roentgen examination as a check-up. In the discussion the conclusions of Eisler were substantiated by Reimann and Mahler (Prague). Reimann and Windholz (Vienna) and Steiner (Teplitz) also contributed some discussion to this interesting question. Herrnheiser, Schwarz and Windholz, in spite of the great didactic value of gastric kymography, doubted the practical value of this method.

Hutter (Vienna) talked about the roentgen demonstration of the parenchyma of the kidneys. Reiser and Pollak (Prague) discussed the roentgen findings in kidney tumors. Strnad (Prague) discussed the clinical and autopsy findings which lead to

* Translated from the German by Dr. E. T. Leddy, Mayo Clinic, Rochester, Minn.

the demonstration of perforation of the kidney and the pyelovenous reflux. Beutel, Weiner and Pollak (Prague) contributed to the discussion.

Fleischner (Vienna) reported on atelectasis and particularly on that form of collapse in which the parenchyma of the lung is adherent between the blocked bronchus and the wall of the thorax, as the result of which horizontal laminated zones of atelectasis result. Adler (Bokau) pointed to the demonstrations of Monaldi on the elastic forces in the thorax. Kubat and Herrnheiser (Prague) reported their studies on the topography of the vessels of the lung.

Bársony and Koppenstein (Budapest) emphasized the importance of an exact knowledge of the anatomy of the diaphragm and discussed the significance of the various shapes of the diaphragmatic arch.

The second section was on roentgenology of the spine. Reisner (Stuttgart) presented an extensive paper in which he discussed the borderland between the normal and pathologic in the roentgenology of the spine. Jaeger (Aarau) discussed different forms of vertebral fracture. From a physiologic point of view fractures of the spine were classified as flexion fractures and extension fractures. Oftentimes a careful analysis of the roentgenogram will give definite information about the mechanism of the trauma. Altschul (Prague) discussed some diagnostic points which may be obtained from the study of chronic lesions of the spine. Gütig and Herzog (Witkowitz) discussed some of the difficulties of the medicolegal evaluation of spinal injuries and recommended roentgenograms of the whole spine. In the discussion, Steiner (Teplitz) reported some studies he had made of the intervertebral discs and his experiences in spinal fractures. Eisler (Vienna) and Jaroschy (Prague) discussed these same points.

Weil (Prague) reported the results of a ten year study of osteomatosis of large and small joints. Osteomatosis may exist by itself or may arise on some other lesion as a secondary condition. Surprising is the difference between the extent of the process and the violence of its symptoms. Eisler (Vienna) and Kuh (Prague) took part in the discussion.

Canigiani (Vienna) recommended contrast filling of the knee joint with perabrodil for greater precision in the diagnosis of damages to the meniscus. Schön (Dresden) reported his experiences with the use of uroselectan and recommended the exposure bridge which he described.

Löw-Beer (Prague) discussed the question of localization of intracranial tumors, and pointed out that they may oftentimes be demonstrated in a flat plate. Windholz and Beutel (Prague) pointed out some changes in the skull which have no pathognomonic significance.

Beutel (Prague) reported on benign tumors of the orbit such as lipoma, fibroma, chondroma, hemangioma, neuroma, neurofibroma and osteoma.

Herzog (Witkowitz) discussed the so-called Fussgeschwulst in children which shows the changes characteristic of fracture of a metatarsal without pre-existing trauma.

Pokorny (Komotau) demonstrated two cases of osteo-arthropathic form of syringomyelia and a case of unequal nuclei of the head of the femur in a small child.

Jaroschy (Prague) demonstrated a case of congenital deformity of the spine.

Schiller (Wlaschim) and Altschul (Prague) reported their experience in hip joint tuberculosis and discussed the various forms which appear in the roentgenograms.

Epstein and Klein (Prague) reported cases of non-luetic patients in whom roentgenograms of the skeleton closely resembled luetic findings with surprising similarity. Brünauer (Vienna) discussed the difficulty of treatment of a patient. Goldmann (Prague) reported a case of combination of two congenital skeletal diseases, chondrodystrophy and congenital syphilis. Epstein (Prague) emphasized the rarity of this combination and emphasized

the importance of conditions resembling lues in the diagnosis of nonspecific bone lesions.

Therapy. Werner (Brünn) discussed the layout and operation of the Masarykanstalt für Geschwülste "Haus des Trostes" in Brünn, by means of numerous illustrations.

Bandhauer (Prague) reported his experience with roentgen therapy of 21 cases of brain tumor verified histologically and operatively. The treated cases as a rule had a longer postoperative duration of life. Schönbauer (Vienna) reported observations where, after a palliative operation or a non-radical procedure, unexpectedly long freedom from symptoms resulted in some cases of carcinoma. He further reported 2 cases where metastatic tumors were removed from the cerebellum, with marked benefit. Werner noted that Czerny thirty years ago pointed out that unexpected healing of cancer may take place.

Borak (Vienna) reported the results of a procedure in the treatment of breast cancer in which in place of radical operation only the local tumor is removed and then roentgen treatment is given postoperatively to the field of operation and the axilla. With doses below 3,000 r the results are poor; above 3,000 r good. Gütig and Werner recommended that this procedure be used only in those cases who refuse operation.

Friedl (Prague) reported that irradiation after radical operation in cervix cancer improved survival figures by 5 per cent.

Fried (Breslau) reported 7 cases of inoperable gastric cancer who received fractionated treatment and in whom both the changes in the mucous membrane relief as well as the filling defects were markedly reduced. Jacobi (Breslau) reported some poor results of treatment by Coutard's method. Werner reported his experiences. The improvement was usually only transitory yet he did have some cases who had been free of symptoms for ten years. Gütig pointed out the fallacy of overenthusiasm and emphasized that improvements were sometimes noted after simple exploratory laparotomy. Eisler, Borak and Fried rather condemned the doubts of Gütig and pointed out the surprising improvements which may be obtained.

Bardachzi (Aussig) opposed, on the basis of his own experience, the assertion commonly made by surgeons that roentgen treatment is useless in Basedow's disease. Löw-Beer agreed with him completely.

Bardachzi (Aussig) reported the results of roentgen treatment of Heine-Medin's disease.

Löw-Beer recommended for the alleviation of roentgen sickness a salt-oil-cholesterin mixture which may be given in chocolate or in oil emulsion.

Schneider (Bamberg) gave a review of the doses necessary to produce amenorrhea in the various age groups.

Short Wave Therapy. Dessauer (Istanbul) presented a report on the theoretical foundations of short wave therapy, in which he specially considered the question as to whether the so-called specific and athermic effects are possible with short waves or whether they can even be demonstrated.

Kowarschik (Vienna) presented a report on the present status of short wave therapy. The dielectric conductivity of the short wave current produces a heating effect in layers of the body in which diathermy currents are insufficient. As a short wave generator he used spark-gap apparatus and valve apparatus; the latter are more efficient. He then illustrated some of the different indications for short wave therapy.

Urbach (Prague) also reported the indications and contraindications for short wave therapy. Strict contraindications are malignant tumors as well as all diseases which have disturbances of temperature sense. He differentiated two groups: (1) the distance treatment by Schliephake's method as well as the most athermic radiation by the Liebesny method; (2) the so-called short wave diathermy and short wave pyrexia.

Liebesny (Vienna) discussed the most athermic short wave method of treatment in which all measurable or sensible heating

effect is avoided. Each short wave method of treatment which has a thermic effect is risky. Athermic short wave treatment is biologically effective and by it the same curative results can be obtained. Pätzold (Berlin) discussed special questions of short wave therapy and particularly the technical aspects of the problem of dosage. Comprehensive experiments in an exact method of measurement have not yet been completed. Tomberg (Vienna) reported on the experimental determination of the specific thermic properties of electric short waves in which he carried out experiments on both living and dead objects. Fried (Breslau) prefers roentgen rays to short waves in the treatment of inflammatory lesions, especially because of the danger of burns. Liebesny insists that burns result only from poor treatment, and recommends as did Brünner-Ohrenstein (Vienna) short wave therapy for furunculosis. Tomberg (Vienna) opposed the idea of an athermic treatment as each object must be heated up. With reference to point heat Tomberg supported Dessauer in the sense of better defining specific thermic effects. Königer (Brünn) discussed his resonator theory which explains the effect of short waves on homogeneous objects and particularly the specific effect of the waves by which the point heat theory can be correlated with the resonator theory. Dessauer, in conclusion, discussed extensively the conception of point heat and emphasized that naturally such heat points can arise without any noticeable general bodily effects. There therefore is no contradiction between the theory of point heat and an athermic effect, because the expression athermic takes for granted the absence of a general heat effect.

Mukden (Vienna) discussed the indications for treatment with the "Tonisators-schwellströmen."

Radium therapy. Brünauer (Vienna) discussed treatment with weak radium preparations in dermatology by means of radium emanation salts and radium metal compresses.

Rosenberg (Berlin) discussed the preparation of radon salve and the biologic effects from its use. Tschelnitz (Brünn) discussed his experiments to increase the activity of radium preparations by means of active charcoal in which he obtained negative results.

Kornalik (Kolin) reported some biologic effects of "buried radiation." In a second presentation Kornalik explained the activation of therapeutically effective substances by which a combination of pharmacologic and radiating components is produced and reported some experiments on the activation of colloidal magnesium hydroxide.

Papers of a General Nature. Dessauer (Istanbul) gave a paper in which he attempted to correlate biologic processes with climatic factors. In discussion Gütig stated that at certain times not only diseases but also accidents occurred more frequently. Kalmus pointed to the fact that this would lead to a better conception of dust-borne diseases. Werner asked whether the condition of sensitive people might not be changed by the accumulation of electrically charged dust particles. Borak (Vienna) and Meier (Braunau) pointed out the rôle of temperature changes in the origin of the various races. Altschul and Haurowitz called attention to the fact that non-radioactive substances, for example, potassium, may send out radiation. Imhofer pointed out the seasonal variation in stammerers. Fischl (Prague) opposed the idea of Dessauer with reference to the effect of charges and radiation on rickets.

Gütig (Witkowitz) reported an unusual case in which a sarcoma developed in the scar of a roentgen carcinoma. Werner reported a case of ovarian carcinoma improved by irradiation in which a spindle cell sarcoma developed in the atrophic skin. Windholz (Vienna) denied the theoretical possibility of a sarcoma arising after roentgen treatment. In the cases described we were dealing with so-called carcinosarcoma, the carcinomatous nature of which was demonstrated pathologically.

Technique. Vogt (Berlin) reported some

theoretical considerations of exposure in tomography which permits the demonstration of various layers of the body.

Nitzge (Berlin) reported a new method of high tension protection of the tube by wire netting.

Franke (Berlin) reported the difficulties of dosimetric technique by the Chaoul method of "near treatment." The name contact therapy is incorrect, because it is impossible to work closer than 3 cm. As the most suitable measuring instrument he recommends a chamber phantom with the Nomentandosismesser of Ernst. Strauss (Vienna) has constructed a special chamber as accessory to his Mecapion for measuring "near radiation."

W. ALTSCHUL

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DEPARTMENT OF TECHNIQUE

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THE ROENTGEN EXAMINATION OF THE CHEST

A NOTE ON THE USE OF AN OPAQUE PLASTIC

By J. GERSHON-COHEN, M. D.
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THE use of an opaque plastic to obtain with a single exposure, satisfactory detail of both lungs, in one of which might be a tumor, loculated effusion, atelectasis or cirrhosis following thoracoplasty, was recently suggested by our technician, Samuel Wein and by Mr. C. W. Smith, of the Eastman Kodak Company.

In the diagnosis and treatment of pulmonary tuberculosis, serial roentgenograms are practically indispensable. Films of uniform density are obtained with difficulty because of many technical factors impossible to duplicate consistently and because of the changing pathological conditions in the lung parenchyma and pleura from time to time during the course of the disease. Pleural effusion, empyemata, tumors and thoracoplasty cause changes in the thickness of tissues and depth of solid structures traversed by the roentgen rays, resulting in a marked difference in roentgenographic densities. An exposure gauged to best demonstrate the parenchymatous processes on the healthy side results in various grades of incomplete exposures on the contralateral involved side. On the other hand, an exposure made to bring out the details on the side with the increased density of tissues causes such a marked increase in the roentgenographic density of the healthy side as again to obliterate all structural details. A Potter-Bucky examination of the chest to bring out the details of an effusion, tumor or

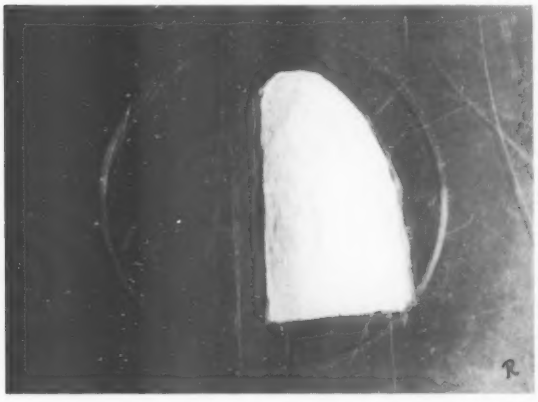

Fig. 1. The opaque plastic spread on the right side of transparent filter to block rays traversing right or healthy side of chest. The film-target distance being 72 inches, the plastic is 6.5 cm. in height (from apex to base), 3.5 cm. in width across the base and about 2 mm. in thickness with rounded edges. This is the size for an average chest; the dimension may be increased about 3 mm. for a large chest and this may be used as a stock filter for all chests, large and small.

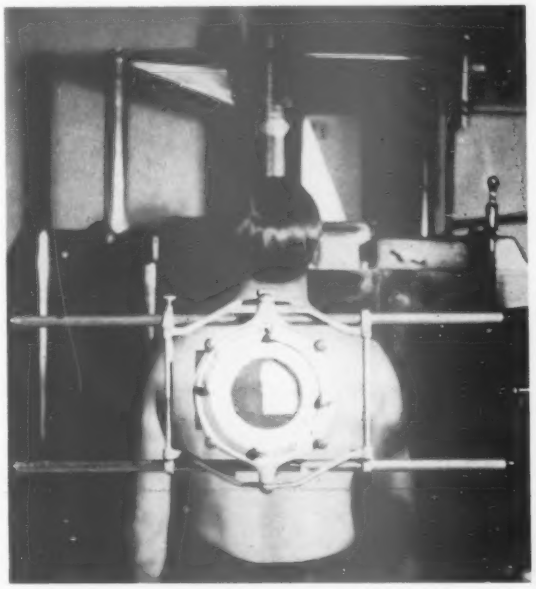

Fig. 2. This shows the transparent filter (made of celluloid) in place in the tube carriage, with the opaque plastic blocking the rays that traverse the patient's right chest.

FIG. 3. A left-sided atelectasis and loculated empyema in a film exposed with the routine chest technique.

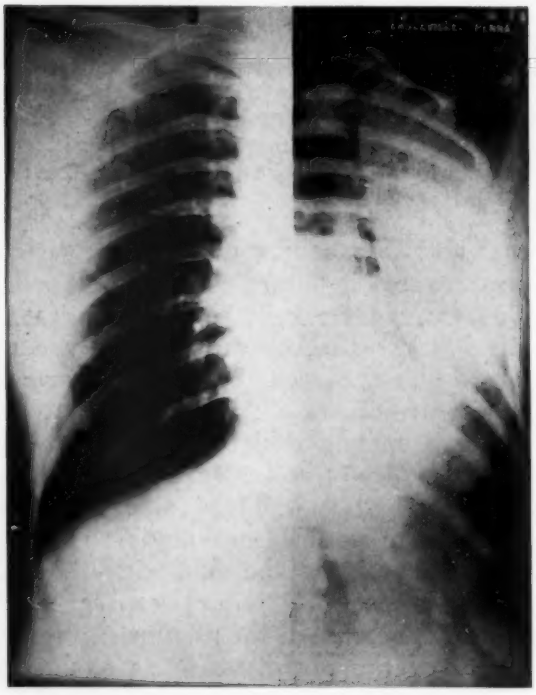

FIG. 4. A Potter-Bucky examination of left side of same chest as in Figure 3.

cirrhotic lung after thoracoplasty is frequently very helpful. This brings out well the details of the diseased or resected ribs, the boundaries of a loculated collection, fluid levels under thick layers of pleura or residual small cavities that might be present in dense fibrotic residual lung parenchyma after thoracoplasty. But such a film is naturally over-exposed for demonstrating details of the healthy side. In order to obtain most from roentgen studies of the chest after thoracoplasty, we had resorted to the Potter-Bucky examination of the operated side and a separate examination of the healthy side on the other half of the same film, using the usual routine exposures for lungs, very much like that described that by Sampson.

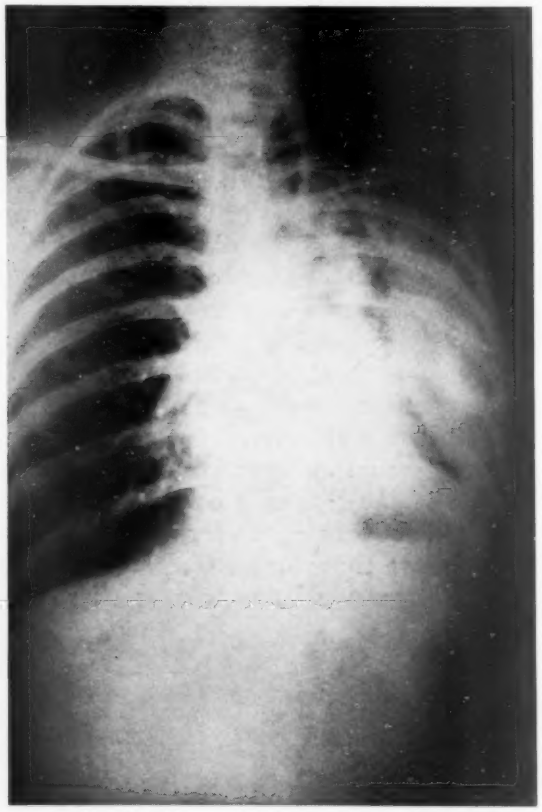

FIG. 5. Same chest as in Figure 3, the opaque plastic used to block the roentgen rays through the right lung.

Recently, we have further improved this technique by the use of an opaque plastic. This is a putty-like substance resembling

modelling clay, containing barium. A transparent filter is placed in the carriage for the roentgen tube and this clay is spread on this transparent filter in such a way as to block out the rays passing through it that would normally project the lung of the healthy side onto the film. By putting the eye in the position of the target of the tube and sighting the patient's chest through the transparent filter, one can quickly draw in the area on the filter corresponding to the half of the chest to be blocked out. The opaque plastic is then put on the filter in this area in a layer varying in thickness from 2 to 4 mm. with rounded edges. The usual technique for chest examinations is then carried out, the exposure voltage selected being that which would ordinarily be used for the diseased side, usually from 8 to 15 kv. higher than for the healthy side. This results in a film showing equally good detail of both the healthy and the diseased or operated contralateral lung with uniform roentgenographic densities on both sides and with no unequal distortion of structures as in those films made with the older technique where a Potter-Bucky exposure was made of one side of the chest and an ordinary exposure of the other.

Fig. 6. A chest after left thoracoplasty exposed with routine chest technique.

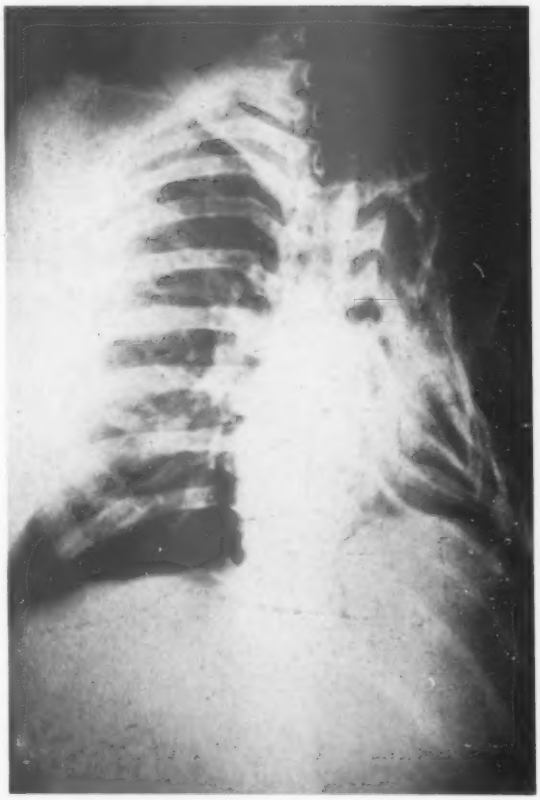

Fig. 7. Same chest as in Figure 6 after the use of an opaque plastic to block the roentgen rays traversing the right lung.

It takes very little time or practice to become familiar with this technique and the improved results obtained seem to warrant a more general application of the method. Since patients with loculated empyemata or other effusions may be quite ill at the time of the examination, stock filters with the opaque plastic on them may be kept on hand for facilitating the study. Two filters can be kept ready, one with the opaque plastic on one side, the other with it on the opposite side. At a film target distance of 72 inches, if a model of the opaque plastic on the filter is made exactly as in the diagram, this can be used for any chest.

LATERAL VIEW OF THE HIP*†

By GERHARD DANELIUS, M.D., *and* LEO F. MILLER, M.D.
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THE visualization of the neck of the femur in the lateral view is essential in the reduction of fractures in this region. A technique has to fulfill the following points in order to be of practical value: (*a*) the roentgenogram has to be taken on a patient who is in the recumbent position —on a fracture table, or in bed; (*b*) the roentgenogram must be taken in a plane perpendicular to the anteroposterior view; (*c*) the femoral neck and head must be projected upon the film without any distortion; (*d*) the roentgenogram should show good bone detail.

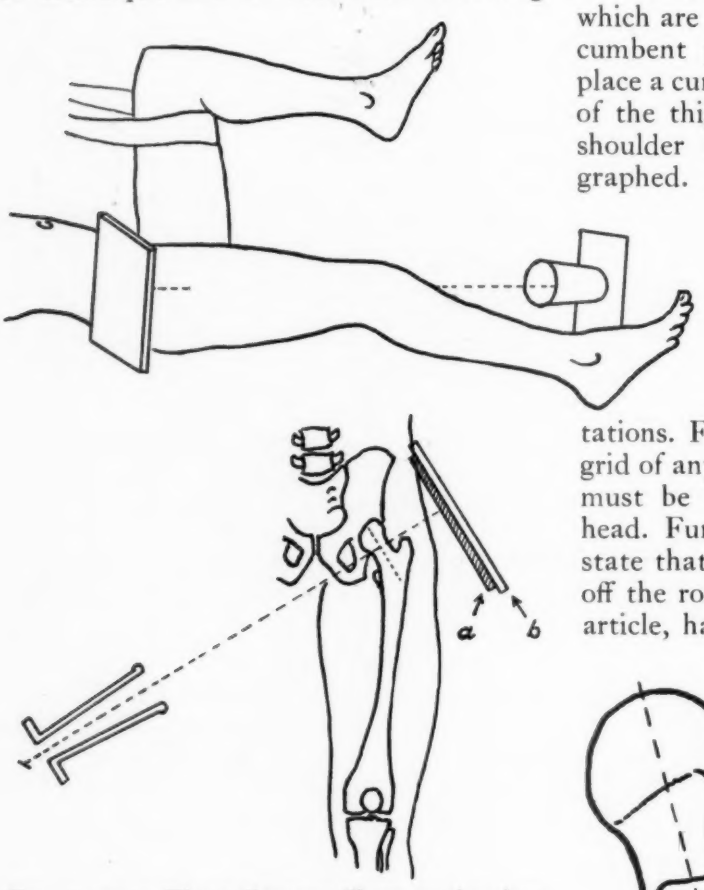

FIG. 1 AND 2. These diagrams illustrate the placement of the patient, roentgen tube, Lysholm grid and film.

There are two methods of visualization of the femoral neck in the lateral view which are taken with the patient in the recumbent position. George and Leonard[1] place a curved cassette on the inner surface of the thigh and place the tube near the shoulder of the side to be roentgenographed. Johnson,[2] on the other hand, places the cassette (not curved) in close contact with the lateral border of the hip joint. The tube is placed near the knee of the opposite leg. In the method of George and Leonard there are some limitations. First, they are not able to use a grid of any construction, and second, there must be some distortion of the femoral head. Furthermore, George and Leonard state that occasionally the head is thrown off the roentgenogram. Jones,[3] in a recent article, has constructed a curved cassette

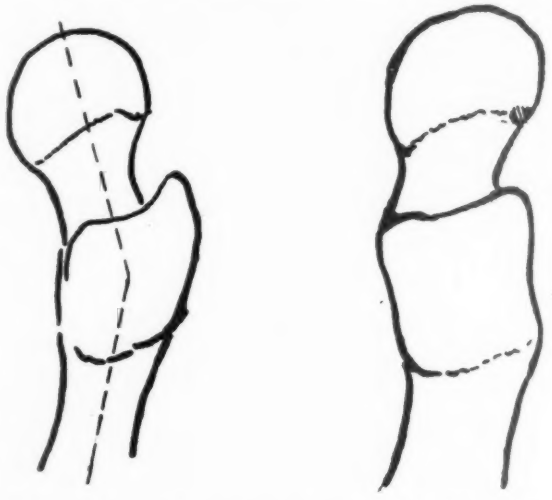

FIG. 3. Comparing the true lateral of the hip region (perpendicular to the anteroposterior view) with a true lateral of the femoral neck.

* From the roentgenological service of Dr. Max Cohn and the orthopedic service of Dr. Charles M. Jacobs, Mount Sinai Hospital, Chicago.
† Received for publication June 20, 1935.

corresponding to the normal angle of the femoral neck to eliminate distortion, but it is felt that when there is some deviation of the angle of the femoral neck, there will be a marked distortion visualized on the roentgenogram.

Our technique for the lateral view of the femoral neck is a modification and simplification of the method described by Johnson. The changes are as follows: (*a*) the technique can be adapted to the variations in the angle of the femoral neck so that a true lateral view can be taken; (*b*) the use of the Lysholm grid gives a much more detailed roentgenogram; (*c*) the film is taken exactly perpendicular to the anteroposterior view with no tilting (see Figs. 1 and 2).

The patient is placed in the recumbent position and the usual anteroposterior view is taken. The angle of the femoral neck is then measured and this gives information as to how to project the central ray and to place the cassette. The patient is then placed upon a small firm pillow which does not extend beyond the trochanters.

The cassette and Lysholm grid are placed exactly vertical to the table, and exactly parallel to the femoral neck as seen on the anteroposterior view so that the cranial edge of the grid and cassette is in close contact with the soft parts at the iliac crests while the caudal portion is always placed away from the body (see Figs. 1 and 2). The Lysholm grid is very sensitive to any tilting and it is advisable to place it with the parallel lead bands in the horizontal position. Particular attention must be given to its proper placement. The cassette and the grid are supported by means of

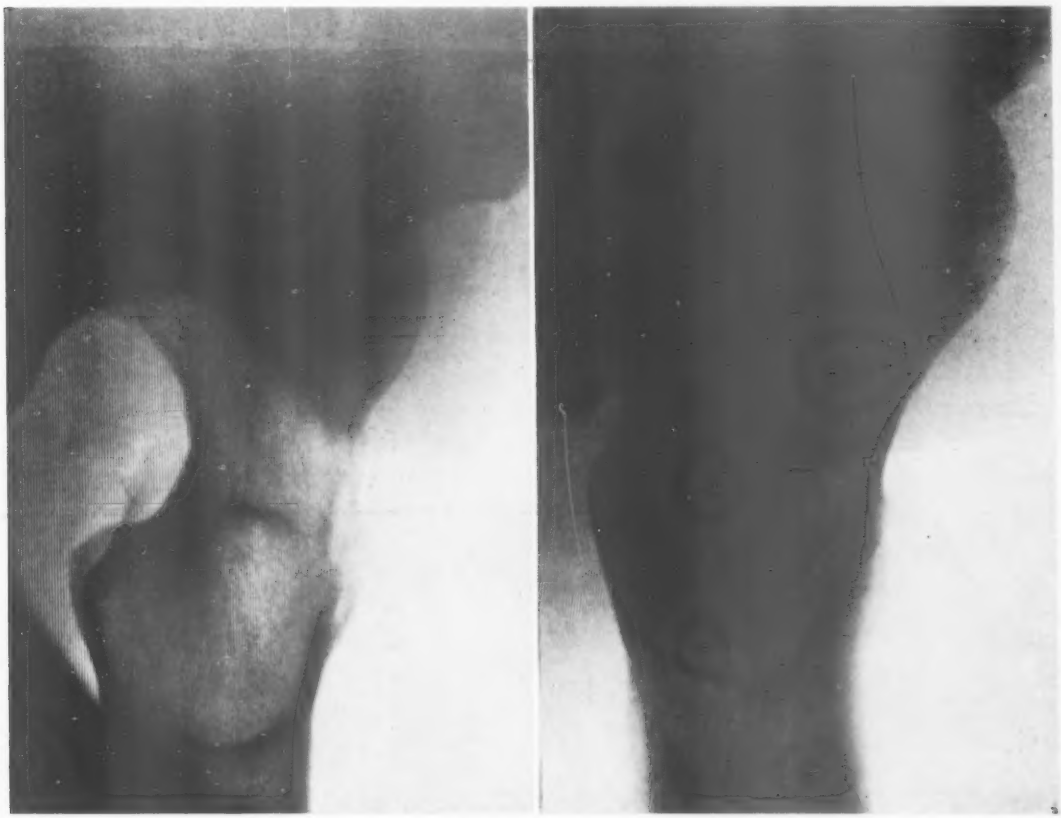

Fig. 4. Showing two lateral views of the hip region with our technique. Note the difference of the dorsal slope in the above illustrations.

sandbags. The tube is placed at a distance of 40 inches so that the central ray is directed exactly perpendicular to the femoral neck and parallel to the table. The leg of the non-involved side is flexed at the hip and knee joint for an angle of 90° and

posterior view; thus it should be noted that our technique demonstrates the exact lateral view of the hip joint, and not of the femoral neck, so that the dorsal slope of the neck of the femur is well visualized. The films, as shown, are self-explanatory.

a *b*

FIG. 5. Fracture of the neck of the femur: (*a*) anteroposterior view; (*b*) lateral view showing the fracture very definitely.

is held by means of a broad linen bandage. The average exposure in our equipment is (mechanical rectifier) 82 kv. (peak), 25 ma., 20 sec.

It is not within the scope of this paper to elaborate on the various pathological processes in the lateral view but to demonstrate the results of the technique. As described above, the roentgenograms are taken exactly perpendicular to the antero-

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

HEAD

Straus, David C. Tuberculosis of the flat bones of the vault of the skull. *Surg., Gynec. & Obst.*, Sept., 1933, *57*, 384–398.

The author reports 3 cases of this rather uncommon condition. Tuberculosis of bone usually begins in the cancellous portions. The condition in the skull is almost always multiple and is secondary to a focus elsewhere in the body, usually the chest. It constitutes about 1 per cent of all bone tuberculosis and occurs most frequently in males, 69 per cent. The frontal and parietal bones are those most frequently involved. There are two types: (1) The circumscribed (perforating) type. The initial focus begins as a localized area of granuloma formation within the diploë, which slowly develops in size and presents the typical, rarefying osteitis seen in the other flat bones. There is usually greater destruction of the internal table. There may be small "millet seed" sequestra present. There is a punched out defect through the entire thickness of the skull. The bone and periosteum up to the very edge of the perforation look entirely normal. There is no hypertrophy and there are no osteophytes. The perforation is usually round and is surrounded by a narrow zone of rarefying osteitis. The areas vary in size from several millimeters to several centimeters in diameter. If the perforation of the entire skull is complete, with a fluctuating mass beneath the skin, pulsation may be observed. Tuberculosis of the external table alone is sometimes encountered, especially in infants and is usually of a mild type. (2) Progressive infiltrating tuberculosis of the skull. In this type the diploë and inner table are progressively invaded with unlimited spread and formation of an extensive sheet of tuberculous granulations between the dura and inner table. The cranial sutures do not offer any barrier to the spread of this type of the disease.

Symptoms. The appearance of a swelling on the head is usually the first intimation of the condition. There may be headaches or rarely epileptiform seizures due to pressure from a granuloma. Constitutional symptoms depend largely upon the primary lesion, the bone condition itself rarely causing marked constitutional symptoms.

Diagnosis is dependent largely upon the roentgenologic findings, upon positive Mantoux and von Pirquet tests, and upon smear and guinea pig inoculation. Roentgenologically one

or more sharply circumscribed, punched out looking defects in the bone are seen. There is no change about the punched out area except a slight decrease in density. Differentiation must be made from syphilis, acute and chronic osteomyelitis, osteosarcoma, osteitis fibrosa cystica, hydatid cyst, actinomycosis, lipoma, sebaceous cyst, cephalohematoma.—*J. H. Vastine.*

BECKER, F. Röntgenologisch nachgewiesene Hirnzystizerken bei epileptischen Anfällen. (Roentgenologic demonstration of cysticercus of the brain in epileptic attacks.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, June, 1934, *49*, 587–593.

Becker reports 4 cases with epileptic attacks, in 3 of whom there was definite evidence of tape worm infestation. Roentgenologic study showed calcified cysts in the muscles (more than 3,000) and in 3 patients calcified areas in the brain which seemed to be quite definitely calcified cysticercus cysts. In one case there was a large osteoma in the frontal sinus as an incidental finding. In the second case the calcified foci were predominantly around the arteries in the Sylvian fossa. The interesting roentgenograms are reproduced in the paper. The author concludes with a discussion of the method of dissemination of the parasites and also of the neurologic manifestations of cerebral cysticercus cysts.—*E. T. Leddy.*

DYES, OTTO. Das Röntgenbild der 3. und 4. Hirnkammer. (The roentgenogram of the third and fourth ventricle of the brain.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1934, *50*, 230–246.

Whereas the anterior half of the third ventricle can be easily demonstrated by lateral projection following injection of air, it is not so easy to demonstrate the posterior portion because with the patient in the frontal position the air escapes through the aqueduct. The changes produced by a psammo-endothelioma in the anterior wall and by a glioma in the frontal region in the contour of the anterior horns are so definite that the recognition of these lesions is facilitated. Less definite, although demonstrable, are changes in the contour of the walls in highly situated cerebellar or pontine tumors, although roentgenograms may show that they elevate the posterior wall or the floor of the third ventricle and distort the aqueduct. In those cases where air filling is unsatisfactory iodipin may be used to check up the outline of a portion of the wall. A complete demonstration of the third and fourth ventricles can be obtained by correctly timed rapid exposures checked up by screen examination as the iodipin passes from the anterior horn to the spinal canal. The outlines produced in this way permit exact evaluation of distinguishing characteristics important for differential diagnosis so that—as is illustrated by an example—an olfactory and a suprasellar meningioma may be differentiated. Pontine tumors should always be differentiated from cerebellar tumors because the indications for the correct operation are clarified.—*E. T. Leddy.*

HAAS, L. Die supraorbitalen Pneumatisationen im Röntgenbilde. (Supraorbital pneumatization as seen roentgenologically.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, July, 1934, *50*, 71–78.

Haas points out that pneumatization of the orbital roof and orbital floor may be of great clinical importance in certain cases. He discusses their occurrence in the frontal and ethmoid regions. For exact study of these air spaces three films are necessary: lateral, posteroanterior and one taken in the Waters or Mayer projection. He illustrates typical roentgen findings of these air spaces and discusses their diagnostic and clinical importance.—*E. T. Leddy.*

RATTI, ARDUINO. Contributo radiologico allo studio dei tumori maligni del seno mascellare. (Roentgen contribution to the study of malignant tumors of the maxillary sinus.) *Radiol. med.*, Jan., 1935, *22*, 1–25.

Based on an experience with some 50 cases the author studied the roentgen diagnosis of malignant tumors of the maxillary sinus. It is very hard to diagnose these tumors in an early stage because in the first place the clinical symptoms are slight and the patients rarely come for examination until quite late. And so long as the tumor is limited to the sinus itself the opacity caused by it differs little from that caused by other pathological conditions of the sinus, such as chronic inflammations. But when the tumor extends beyond the sinus and begins to affect the adjacent bones more characteristic pictures are given. The most frequent finding is a loss of substance of the lateral wall of the sinus, which corresponds anatomically to the

tuberosity and the zygomatic process. This can readily be demonstrated roentgenologically. Next most frequent is destruction of the floor of the sinus and the alveolar process. This and destruction of the roof of the sinus are also visible roentgenologically while it is more difficult to demonstrate destruction of the median wall and also of the posterior wall of the sinus because of superposition of other parts. Destruction of the various walls of the sinus may also reveal other parts usually covered by them, as, for example, the spinal column, the petrous portion of the temporal bone and the styloid process, giving significant pictures.

The different projections used are discussed, among which perhaps the most useful is the classical sagittal posteroanterior projection with the head slightly flexed and with the head slightly extended. These projections avoid superposition of the petrous portion of the temporal bone. A number of illustrative roentgenograms are given.—*Audrey G. Morgan.*

Rendich, Richard A. The mastoid roentgenogram. *M. Times & Long Island M. J.*, Jan., 1935, *63*, 7–8.

One hundred mastoid roentgenograms were chosen at random and studied to determine the number and causes of discrepancies between operative and roentgen findings. In 72 per cent roentgenographic interpretation was in complete accord with the operative findings. Twenty per cent of the cases showed roentgenographic interpretation to be in accord with operative findings. In only 8 per cent were the roentgen findings misleading. Most of the discrepancies occurred in patients under five years of age, a fact readily explained by the comparative underdevelopment of the mastoid and the difficulty of securing a satisfactory examination. In 4 cases the pathology was more extensive than was assumed from the study of the roentgenogram. Some of the reports were considered too vague. The roentgen report only applies at the time of the examination; acute mastoid pathology is not fixed. Hemorrhagic mastoiditis invariably presents at operation pathology more advanced than appears from the roentgenogram. Roentgenograms must be of satisfactory quality to be of value in interpretation. History is of value in the roentgenological interpretation. All available information should be considered in the decision for operation.—*W. R. Brooksher.*

NECK AND CHEST

Vaughn, Arkell M. Cystic hygroma of the neck. *Am. J. Dis. Child.*, July, 1934, *48*, 149–158.

Large congenital cystic hygroma of the neck is rare. The occurrence is about equal in males and females. Cases are about equally divided between the right and left sides of the neck. The cyst is usually first noticed in the first four years of life, but may develop at any age up to fifty-eight. Vaughn reports a case of a male infant who presented at birth a large, pearly blue, translucent cystic tumor which was of a size equal to that of the baby's head. It was located on the right side of the neck and shoulder, extending posteriorly to nearly the midline and anteriorly well forward on the thorax, and from the tip of the shoulder to the mastoid process. It was soft and fluctuant and could be easily moved about in spite of its broad attachment. The baby was normal in every other respect. On aspiration, 300 c.c. of blood-tinged serous fluid was removed from the tumor. A roentgen examination after injection of iodized poppy-seed oil, 40 per cent, was made the following day. The anteroposterior roentgenogram of the cervical region showed the injected substance of the tumor mass extending to the right of the cervical region. The opaque solution seemed to be close to the surface. There was no evidence of fistulous tracts communicating with any other cavity. The tumor caused some depression of the right scapula and a definite deformity of the right side of the thoracic wall. The tumor was removed at operation and the patient made an uneventful recovery.

The etiology of cystic hygroma (cavernous lymphangioma) is obscure. Vaughn thinks that since the neck is one of the parts of the body most richly supplied with lymphatics and the origin of cystic hygroma is probably the result of the persistence of the primary lymph sacs or of an island detaching itself from the rest of the lymphatic system, it seems logical that this tumor should occur in the neck rather than elsewhere in the body, with the axilla as a second choice. Since the tumor has an independent power of growth which is sufficient to force itself into surrounding tissue, it has a tendency to work itself outward to the surface at the same time that it attempts to invade deeper structures.

The gross pathologic structure is essentially

that of a mass of thin-walled cysts of varying sizes filled with serous fluid. Microscopically the tumor is described as being of delicate, cobweb-like consistency with large and small interspaces filled with lymph-like fluid. The cyst walls are usually smooth and are lined with a single layer of endothelium.

The cystic hygromas must be differentiated from branchial cysts which are not translucent; from solitary lymph cysts which are invariably translucent and are most commonly situated in the supraclavicular region and which usually make their appearance in adult life; from lipomas which are superficial and reveal no fluid on aspiration; and from thyroglossal cysts and fistulas which are practically always in the midline. If the swelling which may be found is a hemangioma, pressure causes it to decrease in size, and when pressure is removed it slowly refills. A branchial cyst with deep ramifications can give this sign also, by emptying into the retropharyngeal space. Infected lymph glands of the neck, either tuberculous or otherwise, may closely simulate small cystic hygromas. However, the clinical signs of inflammation are usually present, and these glands move on their underlying tissues. An aneurysm usually has a history of syphilis, acute infection or trauma, and pulsates and has a bruit.

The treatment is complete surgical removal if possible. Radium may be used in some cases as a preliminary step to surgical removal, or in cases where complete surgical removal is impossible.—*R. S. Bromer.*

CAPUA, ANTONIO. Immagine ad anello in ulcera neoplastica dell' esofago. (Ring-shaped image in neoplastic ulcer of the esophagus.) *Radiol. med.*, Dec., 1934, *21*, 1414–1426.

Salotti described a new picture which he had seen in peptic gastroduodenal ulcer: an opaque ring surrounding a central clear area. Other authors have seen these ring-shaped images in ulcers of the duodenum and peptic ulcers of the jejunum. None of them have been able to observe the base of the ulcers and therefore to account for the central clear space. Some attribute it to granulation tissue, others to a blood clot filling the base of the ulcer.

The author describes a case of neoplastic ulcer of the esophagus in a woman of fifty-six in which the first examination showed a niche, while the second showed a typical ring-shaped image with a clear center. Autopsy showed the neoplastic ulcer at the site of the ring. The author thinks that the most probable explanation is that there had been a blood clot on the base of the ulcer which had become detached in the interval between the taking of the roentgenogram and the autopsy. The base of the ulcer was clean and did not show any exuberant granulation tissue. The ulcer had bled, as the patient passed blood with the vomitus and with the feces.—*Audrey G. Morgan.*

BAKER, C. F., and MARQUIS, W. J. The roentgenological diagnosis of lesions of the esophagus. *J. Med. Soc. N. Jersey*, Jan., 1935, *32*, 29–32.

The authors discuss the roentgen diagnosis of esophageal lesions in detail and present an analysis of such examinations in 50 individuals with esophageal symptoms.—*W. R. Brooksher.*

FOSTER, JOHN H. Some observations concerning laryngeal neoplasms. *South. M. J.*, Jan., 1935, *28*, 59–62.

In a general discussion of laryngeal neoplasms, the author details the method of dealing with carcinoma: (1) irradiation alone, or combined with surgery, (2) endolaryngeal surgery, (3) laryngeal fissure and (4) laryngectomy. All cases diagnosed as Grade 4 or other radiosensitive types should be given radiation and observed for a time. Aplastic cancer, prone to recur after surgery, is markedly radiosensitive. Irradiation is employed following endolaryngeal removal of small, malignant, pedunculated tumors and results awaited. The great majority of laryngeal cancers are of the flat-cell type, of moderate malignancy, but rather radioresistant, and surgery gives excellent results in their treatment.—*W. R. Brooksher.*